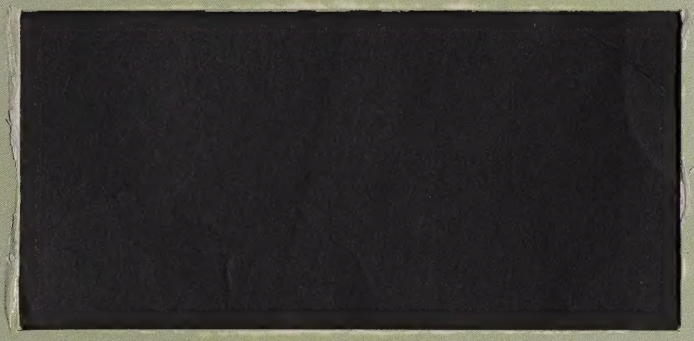

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Warranty

Within one year of purchase, Dana Laboratories will repair or replace, at our option, your instrument if in any way it is defective in material or workmanship. All parts and labor charges will be paid by Dana Laboratories. Just return the instrument to your nearest authorized Dana Service Center freight prepaid. We will return it to you freight prepaid.

DANA

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Dana Model 2850 is a direct-coupled, active guard differential amplifier with low noise at gains up to 2500 (12500 on 2850 V3 option), a high level of common mode rejection, and fast settling time. Full scale output is ±10 volts and ±100mA.

The Model 2850 features variable bandwidth with three pole 18dB/octave filtering. The input, output, and power supply contain RF interference suppression from external RF noise. The Model 2850 provides complete isolation between the two input leads and output common. No common mode return path is required to achieve a common-mode rejection of 120dB, dc to 60 Hz. If desired, the Model 2850 amplifier may also be used as a single-ended unit, inverting or non-inverting, in applications in which either the source or the load is isolated from ground.

A front-panel bandwidth control allows the output to be set at any one of five selected bandwidths: 10Hz, 100Hz, 1kHz, 10kHz, and wideband.

Figure 1.1 - Model 2850 V2 Data Amplifier

Fail-safe circuits within the amplifier prevent damage from short circuits and from fault voltages up to 60 volts common mode (250 V_{CM} on low-gain settings) and 30 volts normal mode. Overload recovery is 2 milliseconds from 500% overload of any duration. The step-function settling time is 500 microseconds.

System noise contributed by the amplifier circuitry is exceptionally low. The noise referred to the input (RTI) at a gain of 1000 is less than 2 microvolts rms at full bandwidth and less than 1 millivolt referred to output (RTO), peak-to-peak, at a 10Hz bandwidth.

1.2 OPERATIONAL DESCRIPTION

A block diagram of the Model 2850 is shown in Figure 1.2. The Input Amplifier contains a Normal Mode Amplifier (NMA) and a Common Mode Amplifier (CMA). The NMA is a differential amplifier that amplifies the differential input voltage. Common mode voltage is effectively "cancelled out" in the NMA by feedback from the CMA. The CMA does this by sensing the common mode component of the signal in the first stage of the NMA and supplying an opposing voltage. The Output Amplifier consists of direct-coupled circuitry that determines the output characteristics of the amplifier. A portion of the output signal is applied back to the NMA through a precision attenuator network as negative feedback to define the closed-loop characteristics of the instrument. Amplifier gain is set by a voltage divider in the feedback network. Precision resistors are switched into this circuit by the GAIN switch.

The Variband* Filter is an Output Amplifier with an active filter amplifier. Capacitors in the filter amplifier are switched with each position of the BANDWIDTH switch to set the upper limit of each bandwidth. The Output Amplifier is capable of delivering $\pm$10 volts full scale output; full scale current output is 100 milliamperes.

1.3 GAIN OPTIONS

Gain controls include specific gain settings, plus a vernier that covers a range equal to 2-1/2 times the nominal gain setting. The result is a continuously variable gain from the lowest setting to 2-1/2 times the highest setting, and it allows the amplifier gain to be used for normalizing ratios, in the case of ratiometer measurements, or scaling a galvanometer trace.

Three gain options are available for various applications and must be specified when ordering the amplifier. They are designated as options V1, V2, and V3.

1.3.1 Option V1

The V1 Option provides gain steps of 20, 50, 100, 200, 500, and 1000. A vernier multiplier extends each gain by a factor of 2.5:1. The V1 Option is especially suited in applications where low-level, millivolt signals are to be amplified to voltage levels for accurate recording or measuring.

*Trademark

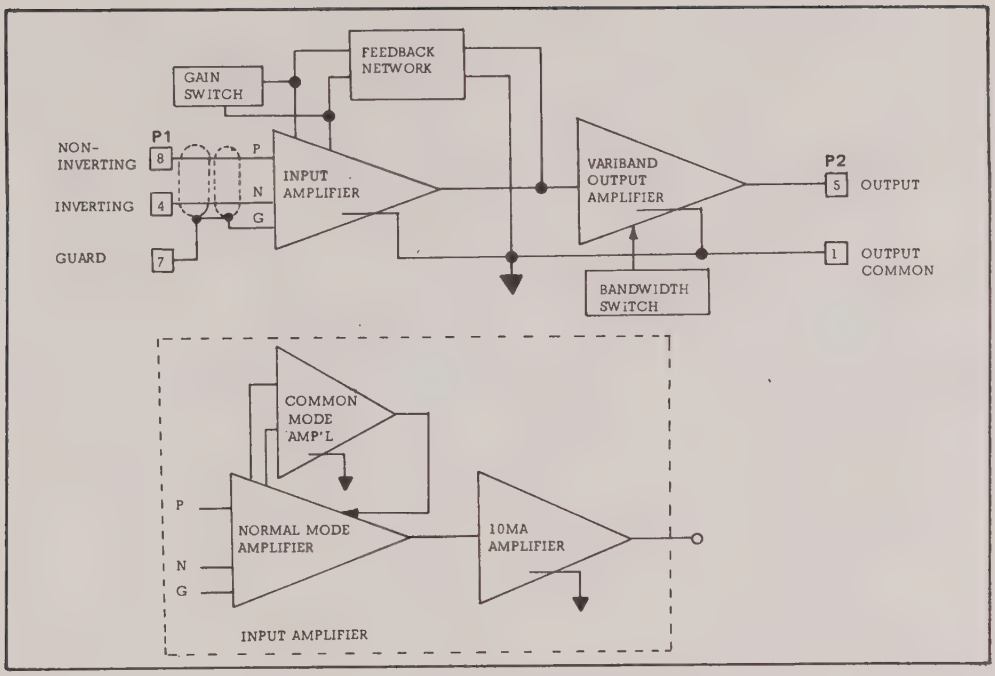


Figure 1.2 - Block Diagram, Model 2850

1.3.2 Option V2

The V2 Option provides the same gain steps as the V1 Option with a gain vernier to extend each gain by a factor of 2.5:1. Option V2, however, includes an X1/X.01 multiplier switch. This feature allows continuous selection of gain values over the range of 0.2 to 2500. The V2 option is especially suited for applications in which the input signal is already at a level of 1 volt or greater, or where the input may vary over a dynamic range from millivolts to full volts. Discriminators, potentiometers, and transformers are typical signal sources of this type and the amplifier serves as an isolation as well as scaling device.

1.3.3 Option V3

The V3 Option provides gain steps of 100, 200, 500, 1000, 2000, and 5000. A vernier multiplier extends each gain by a factor of 2.5:1. This feature allows continuous selection of gain values from 100 to 12,500. The V3 option is especially suited for applications that require an exceptionally high level of amplification such as a thermocouple temperature measuring system.

1.4 SPECIFICATIONS

Specifications are listed in Table 1.1.

Table 1.1. Specifications

DANA MODEL 2850 SPECIFICATIONS

All specifications apply for 0 to 350 ohm sources, in any unbalance.

Gain Option	Range	Steps	Accuracy	Resolution	Stability (at gain setting and constant temperature)	Temperature Coefficient
V-1	20 to 2500 with 2.5:1 vernier	20,50,100,200, 500, 1000	±0.1%	±0.01% (±0.1% worst case)	±0.01% (200 hours)	±0.005%/°C
V-2	0.2 to 2500 with 2.5:1 vernier	0.2,0.5,1,2,5, 10,20,50,100, 200,500,1000	±0.1%	±0.01% (±0.1% worst case)	±0.01% (200 hours)	±0.005%/°C
V-3	100 to 12,500 2.5:1 vernier	100,200,500, 1000,2000,5000	±0.1% K ≤1000, ±0.15% K > 1000	±0.01% (±0.1% worst case)	±0.01% (200 hours) K ≤1000; ±0.01% × K/1000 (200 hrs) K > 1000	±0.005%/°C

	Gain (K) 20 to 1000	Gain (K) over 1000	Gain (K) below 20
OUTPUT (no damage for sustained short circuit)			
Full scale voltage	±10V	±10V	±10V
Voltage overrange, nominal	20%	20%	20%
Full scale load current	±100mA	±100mA	±100mA
Maximum short circuit current	±150mA	±150mA	±150mA
Impedance	0.1 ohm in series with 150uH	0.1 ohm in series with 150uH	0.1 ohm in series with 150uH
Capacitive load, without instability	1uF	1uF	1uF
Capability	Full scale voltage and current to 20kHz	Full scale voltage and current to 10kHz	Full scale voltage and current to 10kHz
FREQUENCY RESPONSE (at full output)			
Wideband			
dc to 100Hz	±0.01%	±0.02%	±0.01%
Minimum 3dB frequency	20kHz	10kHz	10kHz
Variband			
Filter characteristics	3 pole Bessel	3 pole Bessel	3 pole Bessel
Switch selectable cutoff frequencies (f_{co}) of	10Hz, 100Hz, 1kHz, 10kHz	10Hz, 100Hz, 1kHz, 10kHz	10Hz, 100Hz, 1kHz, 10kHz
Attenuation at selected f_{co}	-3dB ±1dB	-3dB ±1dB	-3dB ±1dB
Attenuation above selected f_{co}	-60dB/decade	-60dB/decade	-60dB/decade
Linearity (dc to 2kHz)	±0.01%	$\pm 0.005\% \times \frac{K}{1000}$	±0.01%
COMMON MODE			
Rejection ratio dc to 60Hz	120dB, K = 1000 60dB + K in dB for all other gains	120dB, any gain	60dB, K = 10 40dB + K in dB for all other gains
Operating voltage dc to 60Hz	10V dc or peak ac	10V dc or peak ac	10V dc or peak ac
Fault voltage dc to 60Hz without damage	60V dc or peak ac	60V dc or peak ac	60V dc or peak ac
NOISE			
Full bandwidth	2uV rms RTI +2mV rms RTO	2uV rms RTI +2mV rms RTO	5mV rms RTO, any gain
10Hz	1mV peak to peak RTO, any gain	1mV peak to peak RTO, any gain	5mV peak to peak RTO, any gain
INPUT IMPEDANCE			
Normal mode	10Megohm, parallel with 0.002uF	10Megohm, parallel with 0.002uF	1Megohm, parallel with 0.002uF
ZERO STABILITY			
At constant temperature (after 30 minute warm-up)	±0.02% (200 hrs)	$\pm 0.02\% \times \frac{K}{1000}$ (200 hours)	±0.1% (40 hours)
Temperature coefficient	(±0.0015% RTO ±1uV RTI)/°C	(±0.0015% RTO ±1uV RTI)/°C	(±0.0015% RTO ±500uV RTI)/°C
STEP FUNCTION RESPONSE			
Settles to final value ±0.1% of full scale in	500 usec + $\frac{1.4}{f_{co}}$ sec	1 msec + $\frac{1.4}{f_{co}}$ sec	500 usec + $\frac{1.4}{f_{co}}$ sec
Overload Recovery (to final value ±0.1% of full scale ±10uV RTI) 5 times full scale input, no damage for 30V dc or peak ac input on any gain	2 msec + $\frac{1.4}{f_{co}}$ sec	2 msec + $\frac{1.4}{f_{co}}$	2 msec + $\frac{1.4}{f_{co}}$ sec
TEMPERATURE RANGE (all options)			
Operating	0°C to +50°C		
Storage	-20°C to +75°C		
POWER REQUIREMENT (all options)			
Domestic	105 to 125V rms, 50 to 400Hz, 8 watts		
Export Option 1	200 to 240V rms, 50 to 400Hz, 8 watts		
Export Option 2	215 to 265V rms, 50 to 400Hz, 8 watts		
Export Option 3	90 to 110V rms, 50 to 400Hz, 8 watts		

1.5 LOW-GAIN CONSIDERATIONS

For easier evaluation of accuracy at low-gain operation, pertinent specifications are tabulated in Table 1.2 — in terms of percentage of full scale.

Table 1.2

Gain Setting	Zero Drift/Degree C as % of Full Scale	Error/Volt (Common Mode) as % of Full Scale
1000	0.012%	0.01%
500	0.007	0.01
200	0.004	0.01
100	0.003	0.01
50	0.002	0.01
20	0.002	0.01
10	0.051	0.05
5	0.026	0.05
2	0.012	0.05
1	0.006	0.05
0.5	0.004	0.05
0.2	0.003	0.05

1.6 AMPLIFIER ENCLOSURES

The 2808 Enclosure accommodates eight amplifiers. The enclosure is 7 inches in height with a depth of 22 inches and a width, including flanges, of 19 inches. The basic model is modified by a "dash" number which specifies the type of wiring.

The 2808 Enclosure accommodates all of the Dana Series 2800 Amplifiers. The amplifiers are interchangeable in the enclosure without alteration of the input and output cables.

The -1 Enclosure contains connectors to accommodate system wiring. Fusing and AC wiring are factory wired. An outline drawing (452402) is included in Section 7, Drawings and Parts Lists.

The -2 Enclosure is fully wired. The inputs and outputs are accessible through connectors mounted on the rear panel. An outline drawing (452403) is included in Section 7, Drawings and Parts Lists.

The model 2802-2 enclosure accomodates two 2800 series amplifiers. All 2800 series amplifiers are interchangeable in the enclosure without alteration of the input and output cables.

The 2802-2 can be adapted for bench use or for rack mount use. Dimensions of the enclosure are, height 3.5 inches, depth 20 inches, width 17 inches. Inputs and outputs are accessible through connectors mounted on the rear panel. An outline drawing (402619 page 1 of 3) is included in section 7, Drawings and Parts Lists.

Wiring instructions for each type enclosure are included in Section 2, "Installation".

1.7 AMPLIFIER ACCESSORIES

An Adapter Set Model 2801 (Dana part number 402468) and an Amplifier Support Bracket (Dana part number 452411) are used when the amplifier is operated on the bench. The Adapter Set (item 1 in Figure 1.3) contains input leads, output leads, and the power cord. The Amplifier Support Bracket (item 2 in Figure 1.3) mounts to the amplifier to support the amplifier in an upright position.

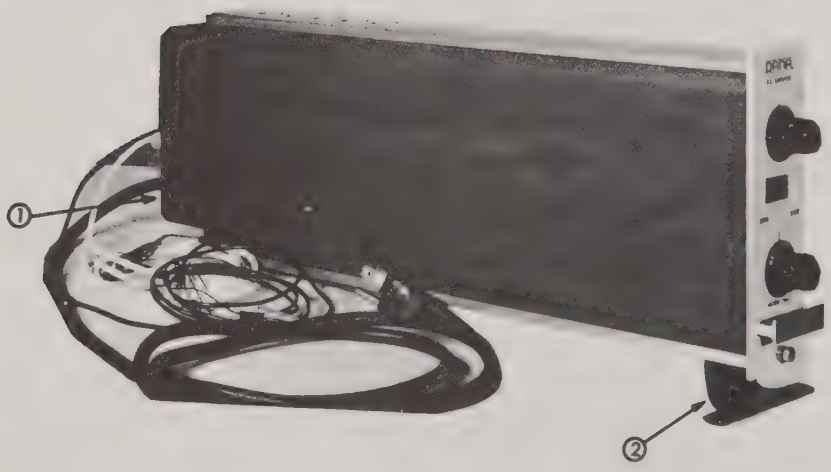


Figure 1.3 - Amplifier Accessories

SECTION 2

INSTALLATION AND CHECKOUT

2.1 UNPACKING AND INSPECTION

The Dana Amplifier is shipped in a special reusable shipping package, designed to protect the instrument from excessive shock and vibration. Examine the package for signs of external damage before removing the unit. If external damage is present, notify the carrier before proceeding. Next, examine the outside of the amplifier for any evidence of damage due to excessive shock, vibration, water leakage, etc.

If the unit appears in perfect condition, proceed with the installation. However, if there is any apparent damage, communicate with the carrier for instructions.

2.2 POWER REQUIREMENTS

Dana Amplifiers, manufactured for domestic use, operate on 115 volts (± 10 volts), 50 to 400 Hz. Units manufactured for export operate on 210 to 250 volts, 50 to 400 Hz. Power required is eight watts.

> NOTE
>
> If the Amplifier has been stored for a prolonged period (5 or 6 months) without use, it is recommended that it be operated with a variable transformer, such as a Variac, at one-half line voltage for about two hours before gradually applying full power. This is done to "reform" the electrolytic capacitors in the amplifier and reduce the chance of capacitor failure.

2.3 INPUT-OUTPUT CONNECTIONS

Input and output connections to the amplifier are through an eight pin connector (P1 and P2) at the rear of the amplifier (see Figure 2.1). External connections are brought in through a mating connector. When the Dana enclosures are used, the mating connector for each amplifier is mounted on the inside back panel of the enclosure; each amplifier plugs into its corresponding connectors. When amplifiers are used singly, a single unit adapter set is normally used. The adapter set (Dana part number 402468) includes the mating connector, power cord, and clip leads for input and output signal connections.

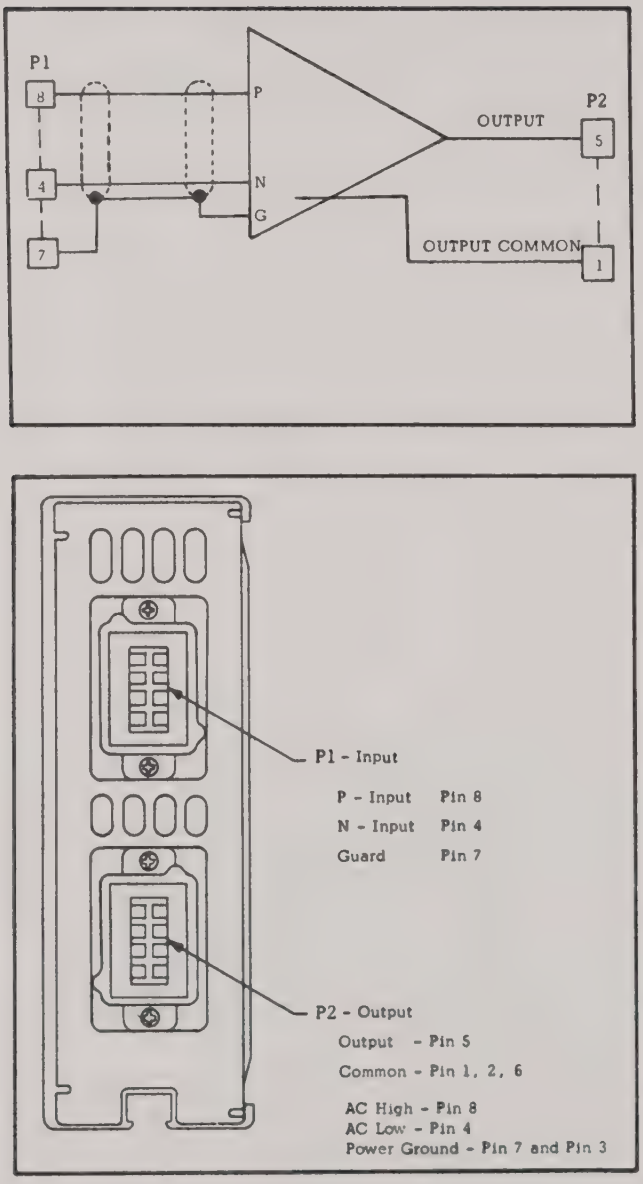


Figure 2.1 - Input/Output Connections

When the 2808-1 Enclosure is used, external connections are made directly to the solder side of the enclosure mounted connector for each amplifier. Access to connectors is gained by removing four screws holding the rear panel and allowing the top of the rear panel to drop away from the enclosure. External leads are routed through the grommet holes and soldered to the connectors.

In the 2808-2 Enclosure, conventional cable connectors are mounted on the rear panel. Connections are made by wiring to the mating connector. All pin connections are identified in Figure 2.2.

2.3.2 Power

When the Amplifier is to be operated within the 2808-1 or 2802-2 Enclosure, power is prewired and a three-wire line cord is supplied. When using the cord set, power and input/output connections are prewired. The power cord is connected to J2 of the cord set.

The ground wire of the power cord connects to the internal power supply shield of the amplifiers.

2.3.3 Input/Output Signals

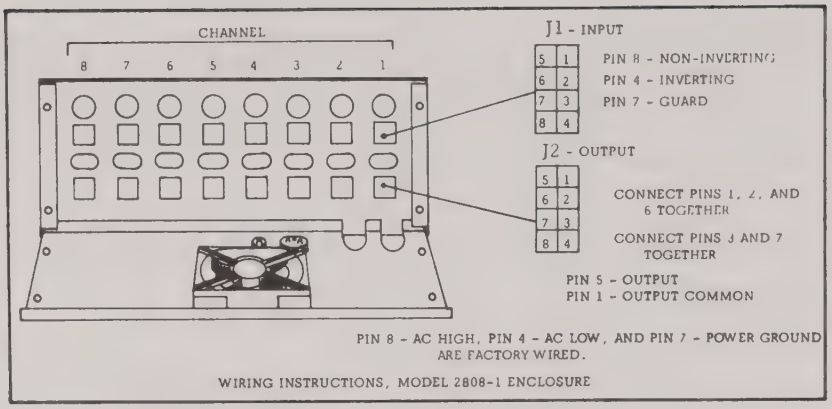
Input wiring configurations are extremely important in minimizing common mode voltages. The guard lead should be connected as close as possible to the signal source. Input and output connections are shown in Figure 2.2.

For permanent installations, low thermal solder (70% cadmium, 30% tin) should be used for all input connections to reduce thermal couple errors. For temporary or test setups, screw terminals or clips having low resistance may be used, taking suitable care to minimize thermal emf's (a few microvolts can be significant on high gain ranges).

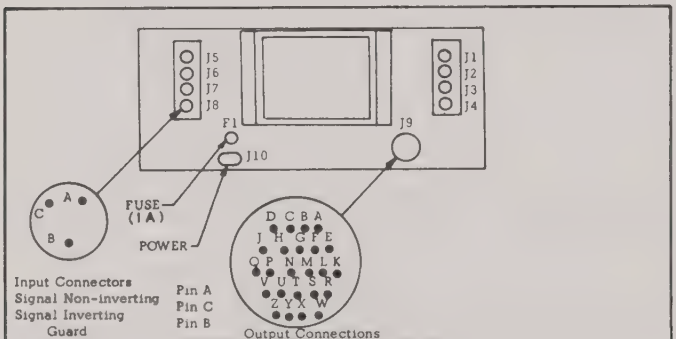
Since P and N inputs to the amplifier are symmetrical (approximately equal impedance to output common), either lead may be connected to either side of the signal source. For phasing purposes, if P is positive with respect to N, the output is positive with respect to output common.

Input leads should be two-conductor in an insulated shielded cable (Belden #8451-500, or equivalent). The shield must be soldered to the guard pin connection (pin 7 of P1 when a -1 Enclosure is used; pin B of the signal input connector for a -2 Enclosure). The unshielded portion of the leads must be kept as short as possible.

A single-conductor shielded cable is recommended for output leads. If two-conductor is used, connect one lead and shield together at either end or both ends. Solder the shield to Output Common (pin 1 of P2 for -1 enclosures; see Figure 2.1 for -2 enclosures). The enclosure chassis is connected to ground by the power cable. The lead from the output common terminal of the amplifier should be connected directly to the input common or ground of the output device.


CHANNEL
8 7 6 5 4 3 2 1
J1 - INPUT
5 1
6 2
7 3
8 4
PIN 8 - NON-INVERTING
PIN 4 - INVERTING
PIN 7 - GUARD
J2 - OUTPUT
5 1
6 2
7 3
8 4
CONNECT PINS 1, 2, AND 6 TOGETHER
CONNECT PINS 3 AND 7 TOGETHER
PIN 5 - OUTPUT
PIN 1 - OUTPUT COMMON
PIN 8 - AC HIGH, PIN 4 - AC LOW, AND PIN 7 - POWER GROUND ARE FACTORY WIRED.

WIRING INSTRUCTIONS, MODEL 2808-1 ENCLOSURE



CHANNEL	OUTPUT	OUTPUT COMMON
1	A	B
2	E	F
3	K	L
4	R	S
5	W	X
6	D	C
7	J	H
8	Q	P

CHASSIS GROUND PIN Z

NOTES: (1) Use shielded two conductor twisted pair cable for input leads. Shield is soldered to Guard Pin Connection.

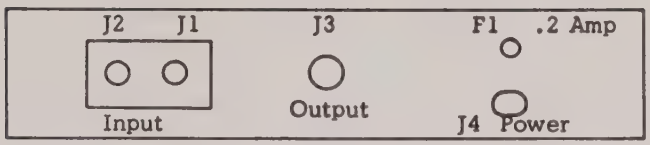
(2) Single conductor shielded wire is recommended for output leads. Solder shield to output common pin.

(3) Viewing enclosure from the front, amplifiers are numbered from left to right.

	Mating Connector & Clamps	Dana Part Number
INPUT (8 sets required)	3106 A-10 SL-3S A105-A115 3057-4A-A105 w/Bush	601561 601474
OUTPUT (1 set required)	3106 A-24-28P-639 3057-16A-639 w/Bush	601563 601564
AC POWER (1 set required)	Belden Power Cord #17256	600127

Wiring Instructions, Model 2808-2 Enclosure

Figure 2.2 - Enclosure Wiring



Input Connectors

Pin A	Signal Non-Inverting
Pin B	Guard
Pin C	Signal Inverting

Output Connector

Pin A	Channel 2 Output
Pin C	Output Common Channel 2
Pin D	Connector Shell
Pin E	Output Common Channel 1
Pin G	Channel 1 Output

Figure 2-3 2802-2 Enclosure Wiring

2.4 INITIAL CHECKOUT PROCEDURES

The amplifier is accurately adjusted and carefully inspected at the factory. The following tests check basic characteristics of the amplifier to verify proper operation upon delivery. The type of damage that can be expected in shipment tends to produce gross malfunctions rather than minor changes in sensitive characteristics. More complete and precise tests and calibration procedures are included in Section 5, "Calibration".

Only three items of test equipment are required to perform initial checkout of the amplifier:

- Audio Oscillator
- Voltage Divider/Attenuator
- Oscilloscope

Standard laboratory-type instruments from any manufacturer may be used.

2.4.1 Gain Checkout

1. Connect the common or ground terminals of each item of test equipment to a single point and to the amplifier output common (pin 1 of P2). Connect this point to ground. Make all measurements relative to this point (see Figure 2.4).

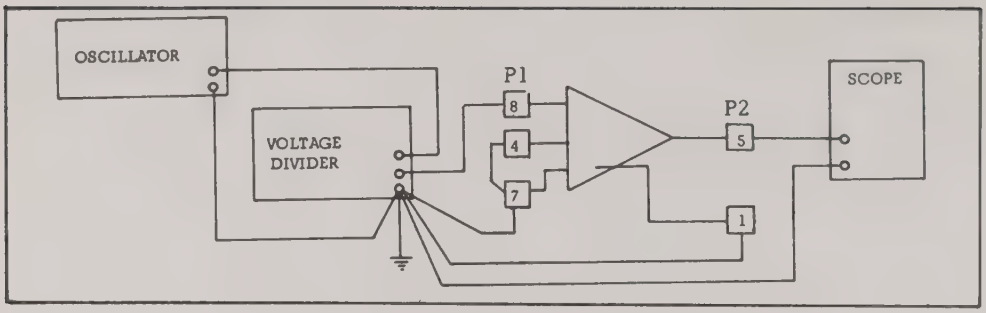


Figure 2.4 - Gain Test Setup.

2. Set voltage divider to minimum output — zero, if possible.

3. Apply power to amplifier. Observe amplifier output on oscilloscope. It should be within a few millivolts of ground and change only very slightly as the amplifier GAIN switch is rotated.

4. Set the VERNIER gain adjustment fully counterclockwise.

5. Set the GAIN selector switch at the highest gain position. If the amplifier is equipped with a Gain Multiplier switch (V2), set it to X 1.0.

6. Remove scope lead from amplifier output and connect scope to the oscillator output. Adjust oscillator for 20 volts, peak-to-peak, at 100 Hz.

7. Set voltage divider to the reciprocal of the maximum gain setting, 1/K. (For example, at maximum gain of 1000, set divider to 0.001.)

8. Return the scope to the amplifier output, pin 5 of P2. The scope should now indicate approximately the same value, 20 volts peak-to-peak, observed at the oscillator output. (The term "approximately" is used because of the limited capability of an oscilloscope to compare two magnitudes accurately.)

9. Verify that there is no obvious noise or other unexplained distortions on the oscilloscope trace.

2.4.2 Frequency Response Checkout

1. Use test setup exactly as connected for Gain checkout. Set amplifier GAIN control at maximum; vernier adjustment to minimum. Connect scope to oscillator output; set oscillator frequency to 20 kHz (gains 20 to 1000; 10kHz for gains below 20 or above 1000).

2. Set oscillator output at 20 volts, peak-to-peak (on scope).

3. Remove scope lead from oscillator and connect to amplifier output pin 5 of P2. Adjust voltage divider for amplifier output amplitude equal to that observed in step 2.

4. Compare voltage divider setting with zero — or minimum output position. The difference should be no less than 3dB, or approximately 30%.

2.4.3 Common Mode Rejection

1. Short the amplifier input leads and the input guard lead (pins 8, 4, and 7 of P1).

2. Connect oscilloscope to amplifier output (pin 5 of P2).

3. Set oscillator output to 20 volts, peak-to-peak, at 60 Hz.

4. Set amplifier GAIN switch to 1000.

5. Observe amplifier output on scope. The output due to common mode is normally not detectable above the wideband noise of the amplifier. Common mode rejection can be calculated as follows:

$$\text{CMR} = \frac{\text{20 Volts (P-P)} \times K}{\text{Output Voltage (P-P)}}$$

Common mode rejection may be measured more closely by following the procedures of paragraph 5.3.1, Section 5.

$$\text{CMR in dB} = 20 \text{ Log } \frac{\text{20 Volts (P-P)} \times K}{\text{Output Voltage (P-P)}}$$

$$\text{Example: CMR in dB} = 20 \text{ Log } \frac{\text{20 Volts (P-P)} \times K \text{ (1000)}}{\text{Output Voltage 20 Mv (P-P)}}$$

$$= \frac{20V \cdot 1 \cdot 10^3}{20 \text{ MV} \cdot 10^{-3}} = \frac{1V \cdot 10^6}{1} = 20 \text{ Log of } 1 \cdot 10^6$$

$$\text{CMR} = 120 \text{ dB}$$

SECTION 3

OPERATION

3.1 MODES OF OPERATION

The Dana Amplifier can be used in any of the four operating modes illustrated below.

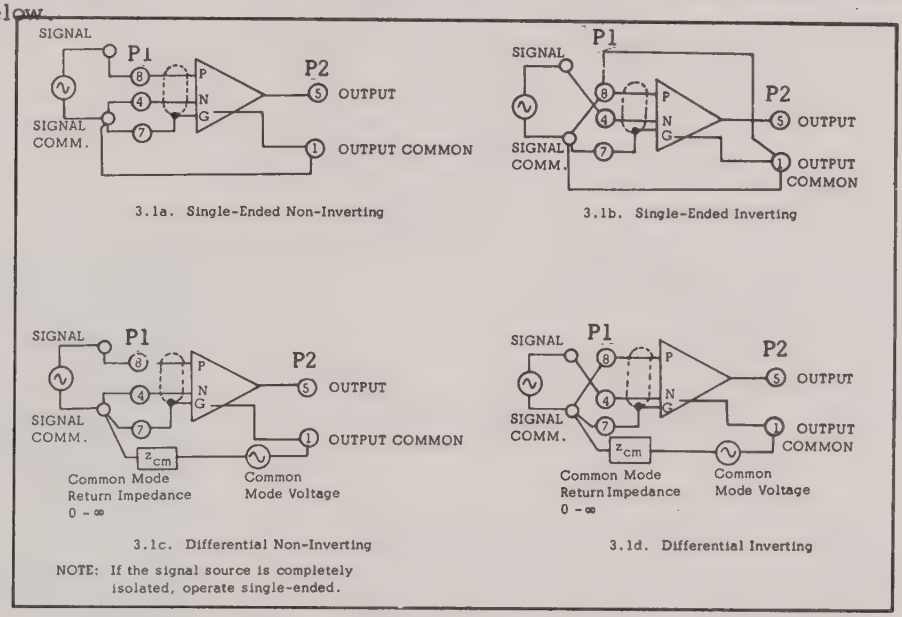


Figure 3.1 - Modes of Operation

3.2 CONTROLS

3.2.1 Gain Selector Switch

The GAIN switch is rotated to select the desired gain of the amplifier. The gains which can be selected vary with the options specified. Gain positions are tabulated below.

Options	Gain Switch Positions
V1 & V2	20, 50, 100, 200, 500, and 1000
V3	100, 200, 500, 1000, 2000, and 5000

3.2.2 Multiplier Switch (Option V2)

The Multiplier Switch is mounted concentrically with the GAIN selector switch. It has two positions, X.01 and X1. In X.01 position, it reduces the gain selected by a factor of 100. For example, effective gains would be 0.2, 0.5, 1,2,5 and 10. In the X1 position, amplifier gain is exactly as inscribed on the switch.

3.2.3 BANDWIDTH Switch

The BANDWIDTH switch allows selection of the amplifier bandwidth. It is calibrated in kilohertz and has the following positions:

Switch Position	Bandwidth
0.01	dc to 10 Hz - 3 dB
0.1	dc to 100 Hz - 3 dB
1.0	dc to 1000 Hz - 3 dB
10.	dc to 10 kHz - 3 dB
Wideband (WB)	Full Bandwidth

3.3 OPERATIONAL ADJUSTMENTS

3.3.1 ZERO Adjustment

ZERO is a screwdriver adjustment on the front panel of the amplifier. It is used to set the output voltage to zero volts with no input. It is adjusted in the following manner:

1. Apply power to the amplifier and any adjoining heat-producing equipment and allow amplifier to stabilize (approximately 30 minutes).
2. Set GAIN selector switch to lowest gain position.
3. Return the input P(P1-8) and N(P1-4) leads to output common (P2-1).
4. Connect voltmeter or scope to amplifier output (P2-5) and common (P2-1).
5. Adjust ZERO for zero amplifier output. Counterclockwise rotation corrects for a positive output; clockwise rotation corrects for a negative output.

2850 - V2

3.3.2 GAIN Adjustment

This is a screwdriver adjustment which serves as a vernier adjustment of gain selected by the GAIN selector switch. The adjustment varies each gain position by a factor of 2.5:1 — providing continuous gain selection throughout all available ranges.

3.4 OPERATING PROCEDURES

After installation of the amplifier as described in Section 2, operation consists simply of selecting the appropriate gain. The amplifier is ready for use immediately with zero stability achieved within 30 minutes.

SECTION 4

CIRCUIT DESCRIPTION

4.1 INTRODUCTION

This section contains an electrical description of each circuit in the amplifier. A block diagram of the Model 2850 is shown in Figure 4.1.

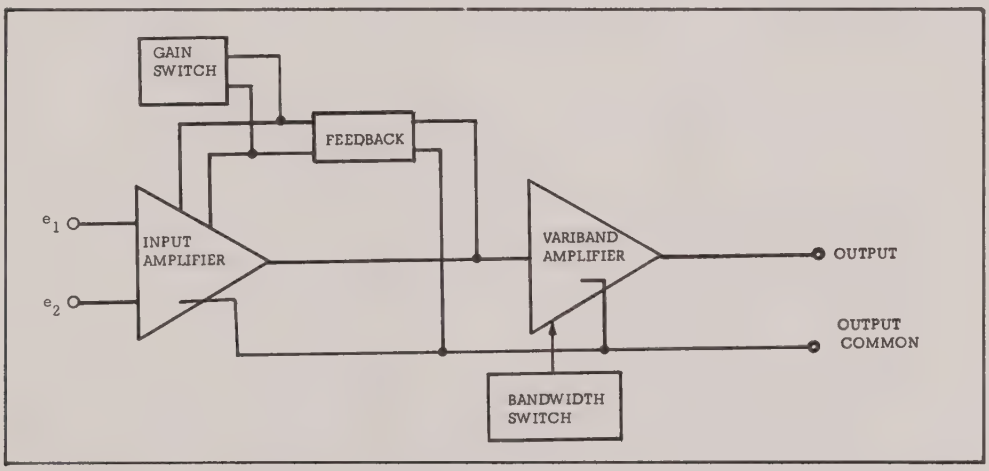


Figure 4.1 - Block Diagram

The forward loop consists of the Input Amplifier and the Output Amplifier. The loop is closed by the feedback network. The Input Amplifier amplifies the potential difference between the two inputs. When one input goes positive and the other input goes negative with respect to common, the output of the amplifier is proportional to the difference of the amplitudes. These signals are referred to "normal mode signal" (also referred to as "difference" or differential signals). The potentials common to both inputs are referred to as "common mode signals" and are rejected by the amplifier. The normal mode signals and the common mode signals are defined on the following page.

Normal Mode Signal $= e_1 - e_2$

Output (E_O) $= (e_1 - e_2)$ (Gain)

Common Mode Signal $= \frac{e_1 + e_2}{2}$

In single ended operation, a signal is applied to one input while the other input is common; therefore, the output is proportional to the amplitude of the one signal applied.

Figure 4.2 shows the amplifier responding to normal mode signals and rejecting the common mode signal (one-half) of the bridge supply voltage. In practical applications, there would be additional common mode potentials due to stray fields and other causes. These potentials, represented by "e_x", are also rejected.

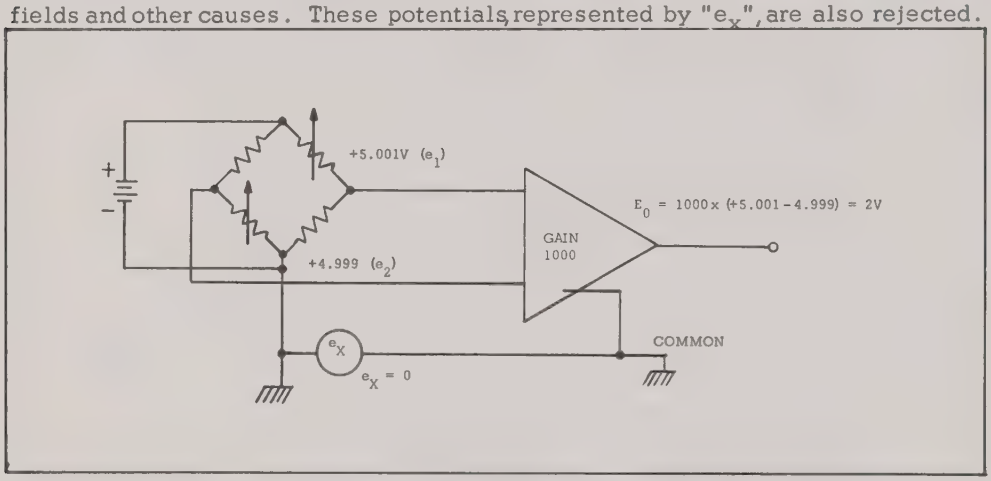


Figure 4.2 - Normal and Common Mode Response

4.2 NORMAL MODE AMPLIFIER

Figure 4.3 shows a potentiometric amplifier. This type of amplifier is a potentiometric device, since the feedback achieves a high effective input impedance by the same principle as the common "null balance" approach to precision measurements. In both cases, the effective input impedance approaches infinity at null. In the potentiometric amplifier, impedance is limited by factors such as leakage and practical values of loop gain.

Examining the feedback system, it can be seen that the feedback is of proper phase to cancel the effect of the input signal; however, the cancellation leaves a small "error" signal of sufficient magnitude to support the 5-volt output. In the example, if the open loop gain (gain without feedback) of the circuit were

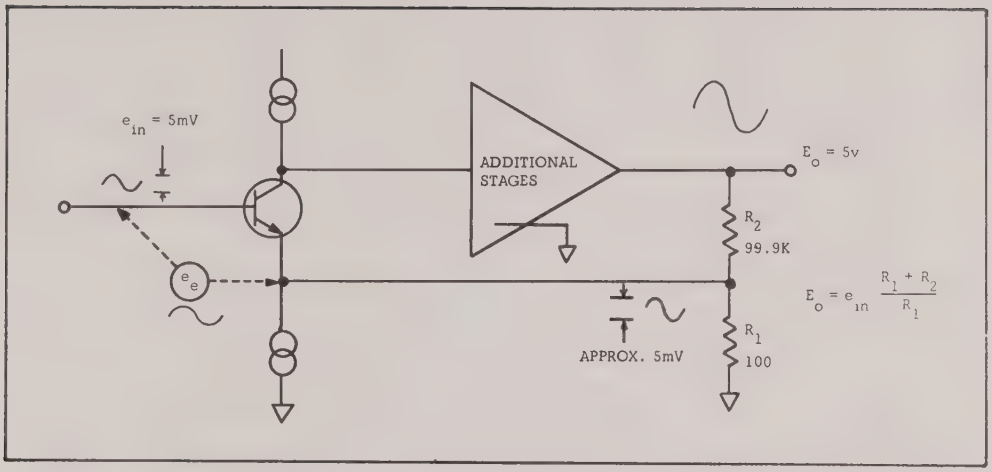


Figure 4.3 - Simplified Potentiometric Amplifier (Gain of 1000)

140 dB, the approximate residual error signal would be $5V/10^7$ or 0.5uV (e_e in the figure).

To achieve the desired gain stability and linearity, the open loop gain is considerably greater than the closed loop gain. By keeping this ratio sufficiently high, the "closed loop" or "net gain" is essentially determined by the feedback elements alone.

Figure 4.4 shows two potentiometric amplifiers connected in a differential configuration. One-half of the normal mode voltage ($e_{NM}/2$) appears at e_1 while the other one-half of the normal mode voltage appears at e_2. As in Figure 4.3, a 5 millivolt signal at each of e_1 and e_2 will be 5 volts output at each potentiometric amplifier. With the differential amplifier stage as shown in Figure 4.5, the outputs of the balanced differential stages are combined in the summing amplifier which transfers one directly and inverts the other. This is in keeping with the normal mode signal characteristics of $e_1 - e_2$. Signals of common polarity or phase will cancel at the summing stage, the degree of cancellation dependent on their relative magnitudes.

Input lines (e_1, e_2) are connected to the bases of a pair of matched silicon transistors (dual transistors in a single case) and circuit parameters are adjusted to obtain equal characteristics in each stage. A unique aspect of the circuit is the technique employed in controlling these parameters for stable operation over wide temperature ranges.

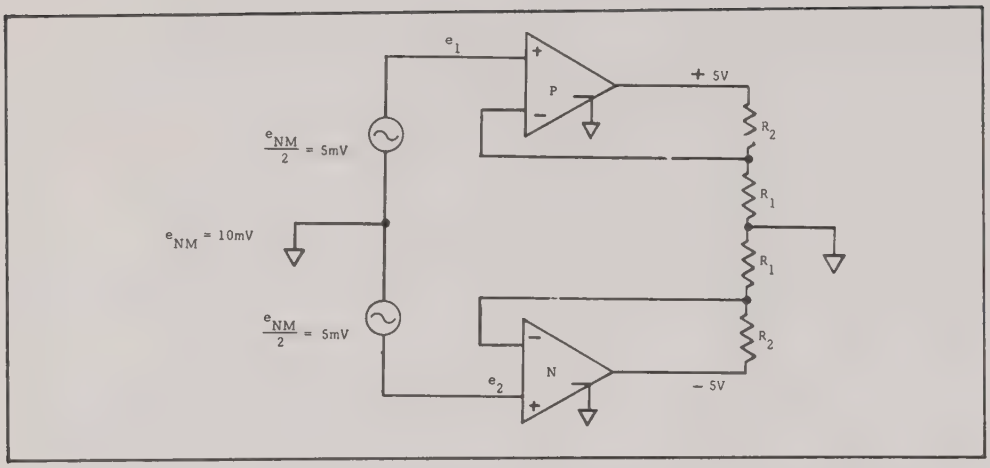


Figure 4.4 - Potentiometric Amplifiers in Differential Configuration

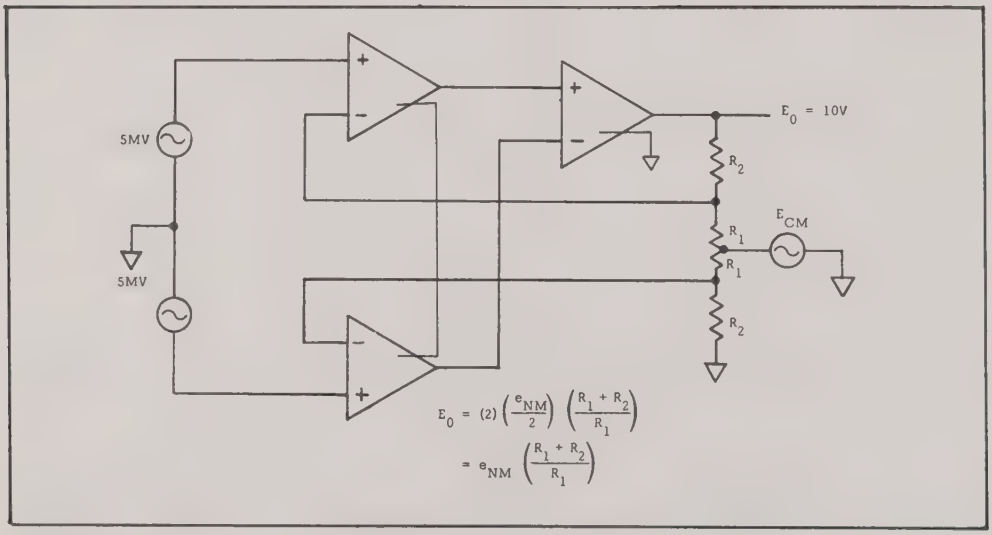


Figure 4.5 - Differential Stage for Summation of Inputs

4.3 COMMON MODE AMPLIFIER

Although the Normal Mode Amplifier provides a degree of common mode rejection (CMR = 60 to 70 dB with balanced source), it is insufficient for high accuracy data systems. The primary deficiency of the circuit is the low impedance between the input lines and common - too low to materially reduce common mode currents. This deficiency is overcome by the use of a separate Common Mode Amplifier

(CMA) which senses the common mode voltage at the input and forces the emitters of the "input pair" of the normal mode amplifier to the same potential (neglecting bias). This "bucking" voltage allows very little current to flow from either input to output common, increasing the intrinsic impedance to common.

Figure 4.6 shows the relationships of the normal mode amplifier and the common mode amplifier. The output of the common mode amplifier (E_{CM}) is connected to the junction of the R_1 resistors.

The voltages, e_1 and e_2, appear at the voltage divider as shown in Figure 4.6. The "bucking" voltage is supplied by the common mode amplifier.

Consider the upper-half of the voltage divider and the lower-half of the voltage divider as shown in Figure 4.7. The upper-half of the voltage divider is bounded by the two voltages E_O and E_{CM}. The voltage at E_{01} is equal to

$$E_{01} = E_O - \left(E_O - E_{CM} \right) \left(\frac{R_2}{R_2 + R_1} \right)$$

and is the "bucking" voltage to effectively cancel $e_{CM} + \frac{e_{NM}}{2}$.

The lower-half of the voltage divider is bounded by E_{CM} and common. The voltage at E_{02} is equal to

$$E_{02} = E_{CM} \left(\frac{R_2}{R_1 + R_2} \right)$$

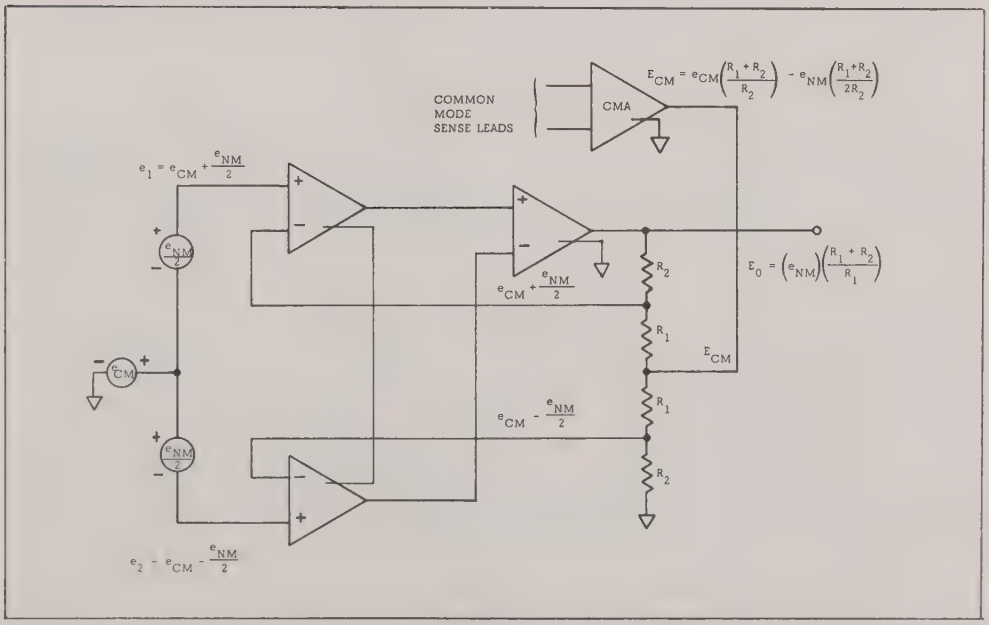


Figure 4.6 - Normal Mode Amplifier and Common Mode Amplifier

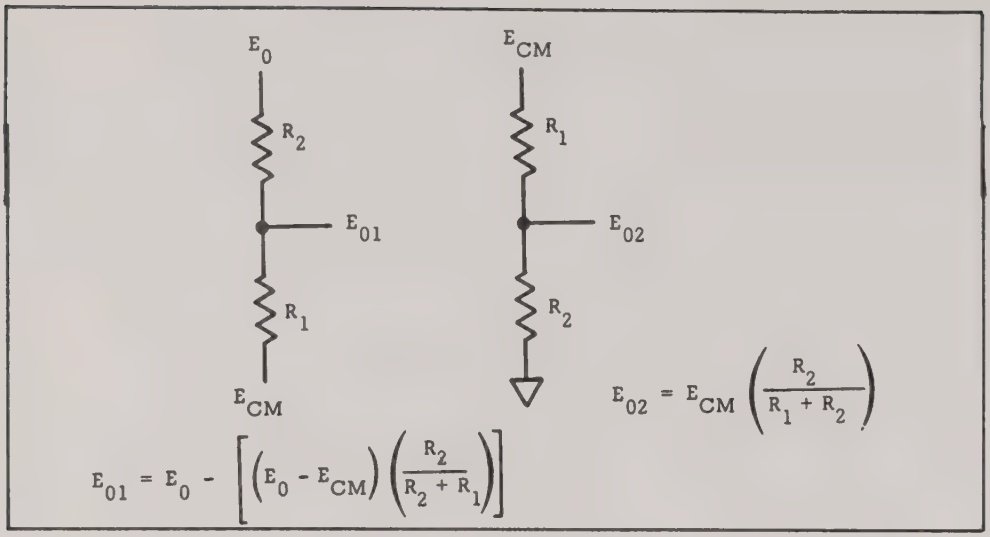


Figure 4.7 - Voltage Dividers

and is the "bucking" voltage to effectively cancel

$$e_{CM} - \frac{e_{NM}}{2}$$

The common mode voltage (E_{CM}) from the common mode amplifier required to satisfy the above equations is

$$E_{CM} = e_{CM}\left(\frac{R_1 + R_2}{R_2}\right) - e_{NM}\left(\frac{R_1 + R_2}{2R_2}\right)$$

The gain of the normal mode amplifier is set by inserting a resistor R_X as shown in Figure 4.8. Resistor R_X does not influence the value of E_{CM} and may be varied without interfering with the common mode compensation.

4.4 INPUT AMPLIFIER

The Input Amplifier can now be shown as in Figure 4.9a. Differential input signals cause out-of-phase signals to be developed across the input pair's respective collector resistors. Under these conditions, the drop across the collector summing resistor (R36 in Figure 4.9a) remains constant; however, a voltage source common to both input lines (e_{CM}) causes in-phase collector current variations which add through R36 and produce a signal proportional to the common mode potential, providing an input to the CMA. As illustrated in Figure 4.9a, the CMA couples a feedback signal to the emitters of the input pair

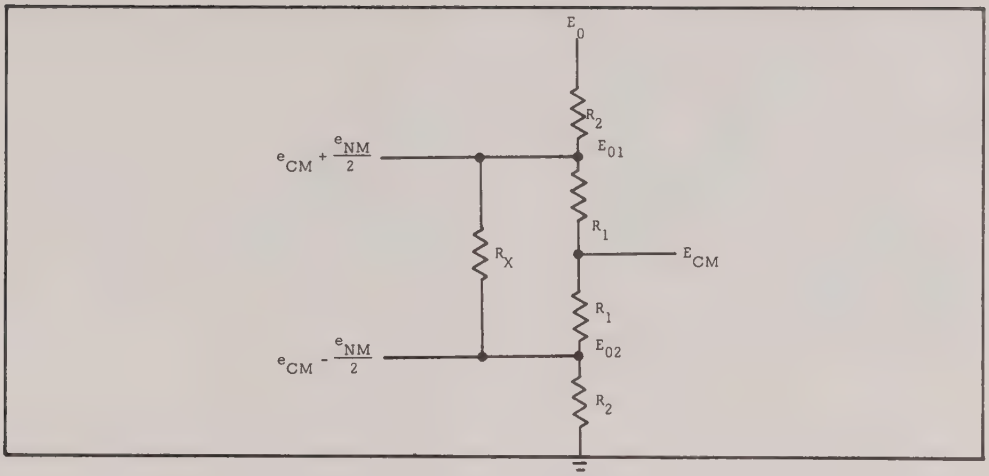


Figure 4.8 - Gain Set

through R42 and R44. This signal is of the proper phase to cancel the effect of the input potential and maintain the sum of the two collector currents constant. Cancellation is complete except for a small residual error voltage necessary to maintain the output of the CMA very near the common mode potential (ignoring attenuator insertion loss).

For convenience, the Common Mode Amplifier (CMA) has been described as if it were a single-ended device referenced to ground. However, the CMA is a differential amplifier much like the Normal Mode Amplifier and, as such, responds to the difference between its input terminals. In the actual circuit, one of the CMA input terminals is connected to the lower side of the input stage collector summing resistor and the other to a passive divider connected between the input pair emitters and the top of the collector summing resistor (Figure 4.9a).

If this circuit is closely examined, it can be seen that the various circuit elements form a simple bridge. This identity is established in Figure 4.9b. In operation, the application of a common potential to the input transistors tends to unbalance the bridge by changing the conductance of the input pair. This effect is opposed by driving the lower end of the bridge (or the emitters of the input pair) with the output of the CMA. This feedback effectively cancels the change in conductance and restores the bridge to balance.

As previously stated, the parameters of the input stage are carefully adjusted for nearly identical characteristics. Once established, they cannot be allowed to change when the circuit is subjected to common mode potentials. From Figure 4.9 it can be seen that the entire input circuit is floating between two

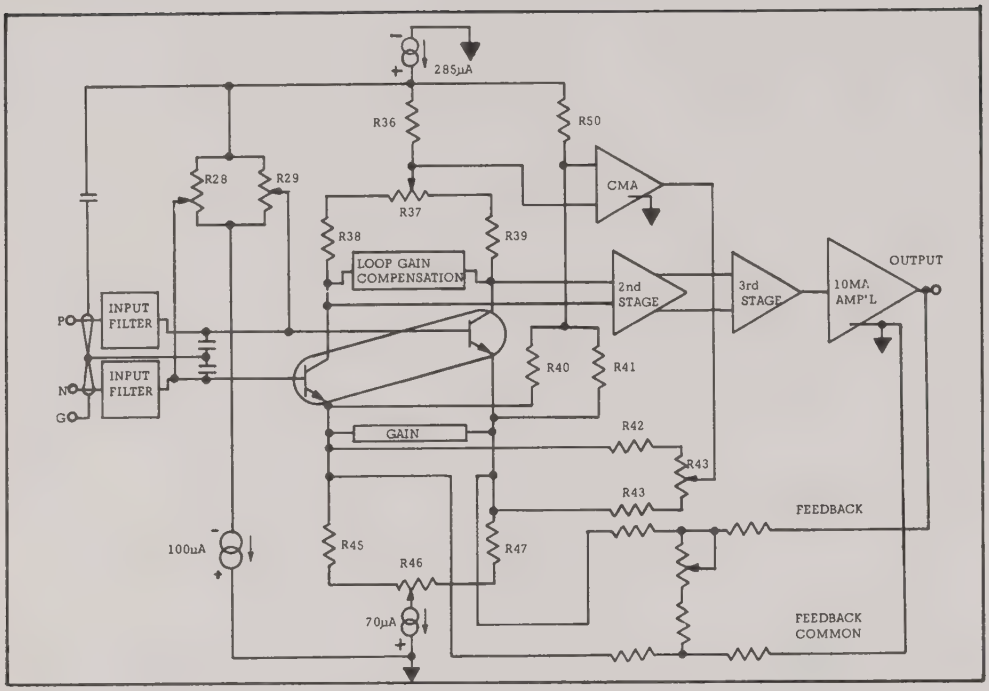


Figure 4.9a - Input Amplifier

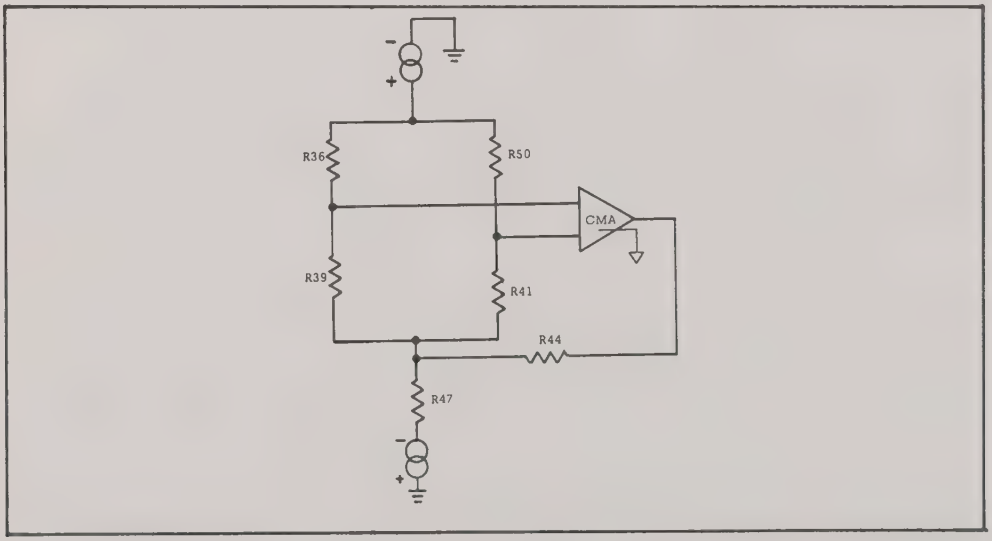


Figure 4.9b - Equivalent Bridge

constant current generators. Since it has been established that the active elements in the bridge circuit (transistors) are continuously balanced against passive elements (R36, R39, R50, R41), it becomes apparent that the constant current sources will also serve to maintain constant voltage conditions across the bridge (constant I x constant R = constant E). This means that, as the lower part of the bridge is driven up and down synchronously with the common mode potentials, the voltage at the top of the bridge varies with the same relative magnitude. This "bootstrapping" effect raises the intrinsic common mode rejection of the input pair to the high values required for high accuracy systems.

Potentiometers R28 and R29 are the N-input and P-input offset-current zero adjustments to minimize the current flow-through the input terminals.

The gain and loop-gain compensation blocks shown in Figure 4.9 are networks selected from the front panel GAIN select switch.

4.5 VARIBAND OUTPUT AMPLIFIER

The VARIBAND OUTPUT AMPLIFIER (Figure 4.10) consists of a single ended amplifier and an active admittance filter. The single ended amplifier is a unity gain, complementary symmetry class AB power amplifier capable of delivering 100 milliamperes into a 100 ohm load; output voltage is 10 volts peak, 20 volts peak-to-peak.

A separate power supply provides a positive voltage and a negative voltage capable of delivering up to 100 milliamperes to the load. The power supply is shown as batteries in Figure 4.11. The current supplies are controlled by common-emitter transistor drivers and are switched to common in accordance with the input signal. Transistor Q36 controls the positive current through the load. As the positive current increases through the load, the output voltage at the common connection node of the current supplies goes negative. As the negative current increases through the load (controlled by transistor Q38), the output voltage goes positive.

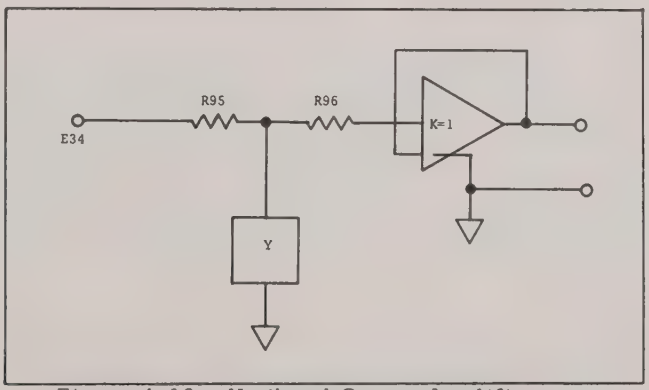


Figure 4.10 - Variband Output Amplifier

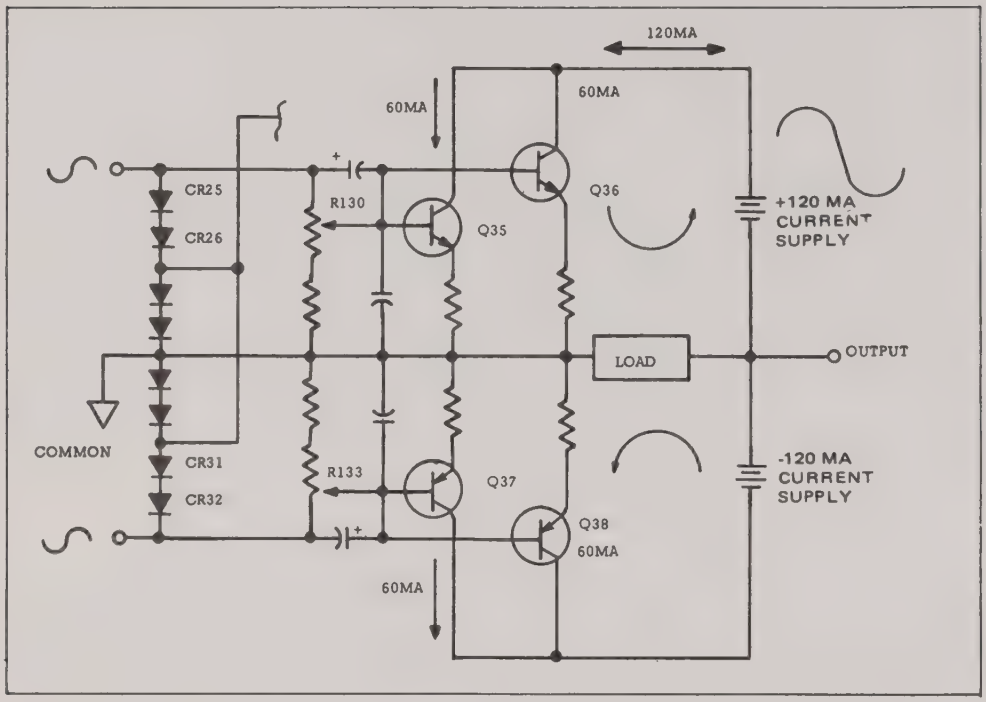


Figure 4.11 - Output Drivers and Current Limiters

The negative current limit is determined by adjusting R130 (500 ohm potentiometer), the positive current limit is determined by adjusting R133 (500 ohm potentiometer). The current adjustment for each potentiometer is approximately 95-150 milliamperes. Diode clamps CR25 and CR26 will conduct when the voltage across either the emitter resistor of the output driver (Q36) or the emitter resistor of the current limiter (Q35) reaches +0.6 volts. Diode clamps CR31 and CR32 will conduct when the voltage across either the emitter resistor of the output driver (Q38) or the emitter resistor of the current limiter (Q37) reaches -0.6 volt.

The short-circuit current limit of the Output Amplifier is approximately 150 milliamperes; the current limit for a 100 ohm load is approximately 120 milliamperes. The Active Admittance Filter (Figure 4.12) consists of a passive RC network and an operational amplifier. The passive network is a 3-pole Bessel filter. The network is driven by an operational amplifier and attenuates the signal by 6dB $\pm$1dB at the cutoff frequency (f_{CO}); attenuation above the cutoff frequency is 18dB per octave, 60dB per decade. One of five bandwidths is selected from the front panel BANDWIDTH switch that selects the capacitors in the passive network.

4.6 FEEDBACK CIRCUIT

The differential input of the amplifier requires a feedback network slightly more complex than the simple divider that was shown in Figure 4.3. To illustrate, consider the case where one input is connected to a positive signal and the other to a negative signal. It would appear that the proper bipolar feedback for both inputs could not be derived from a single output terminal; however, this is not the case.

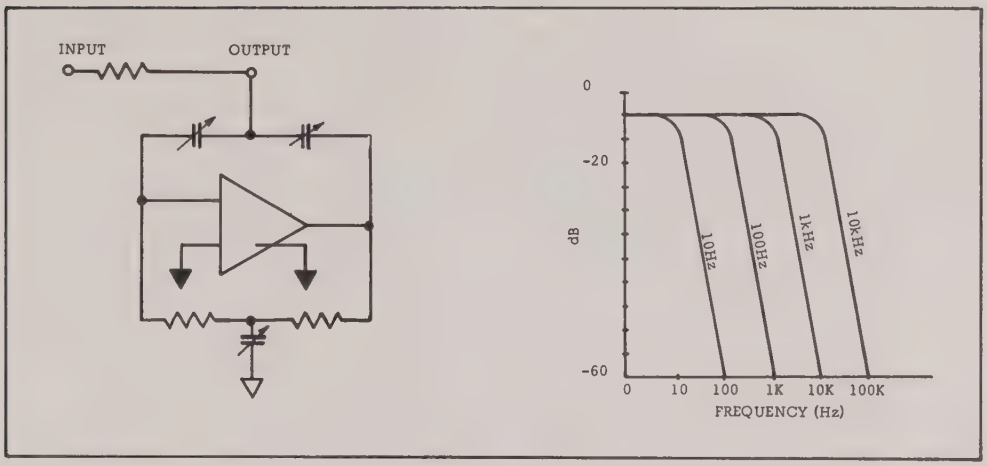


Figure 4.12 - Active Admittance Filter

Figure 4.13 shows the equivalent feedback network of the amplifier. For the purpose of the initial discussion, assume no connection between points A and B, and that the amplifier has somehow arrived at the proper ten-volt output for a ten-millivolt input (gain of 1000). It can be seen that the voltage difference between the two feedback lines is the required 10 millivolts; however, both lines are approximately +5 volts above common. This is obviously intolerable and the circuit will not function until a connection is made between points A and B. It should be emphasized that the +5 volts is common to both input transistors and would tend to unbalance the common mode bridge just as an external common mode potential would do. The only difference in the two situations is the fact that the "feedback" common mode voltage is internally generated and tends to drive the input emitters in lieu of the bases. The latter results in one less phase inversion for internally generated common mode signals, producing an output from the CMA of the opposite output which goes negative until the feedback lines become approximately +5 millivolts and -5 millivolts with respect to common.

It can now be seen that the CMA will not tolerate the bridge to be unbalanced at any time, whether the common mode potential is introduced internally or externally. More specifically, the collector currents are never permitted to shift in the same direction but can only vary by equal and opposite amounts in response to differential input signals. This fact holds true regardless of the symmetry of the input signals. For example, consider the situation where one input is tied to common and the other is driven with a 10 millivolt AC signal. The CMA assumes the proper signal level so that equal and opposite error signals exist between the base and emitter of each input transistor. The final quiescent conditions are shown in Figure 4.14.

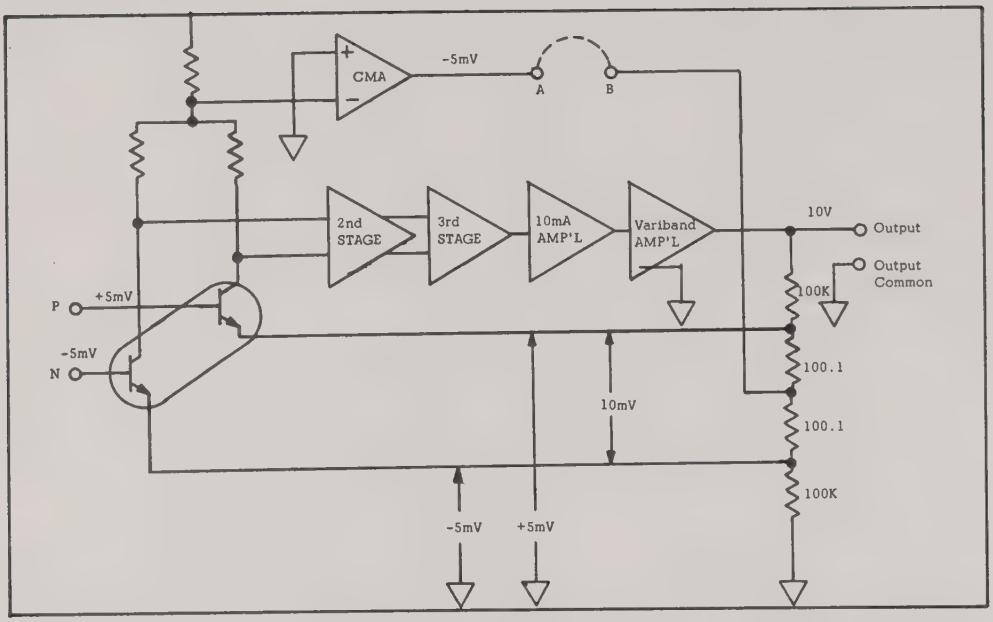


Figure 4.13 - Equivalent Feedback Network for Gain of 1000

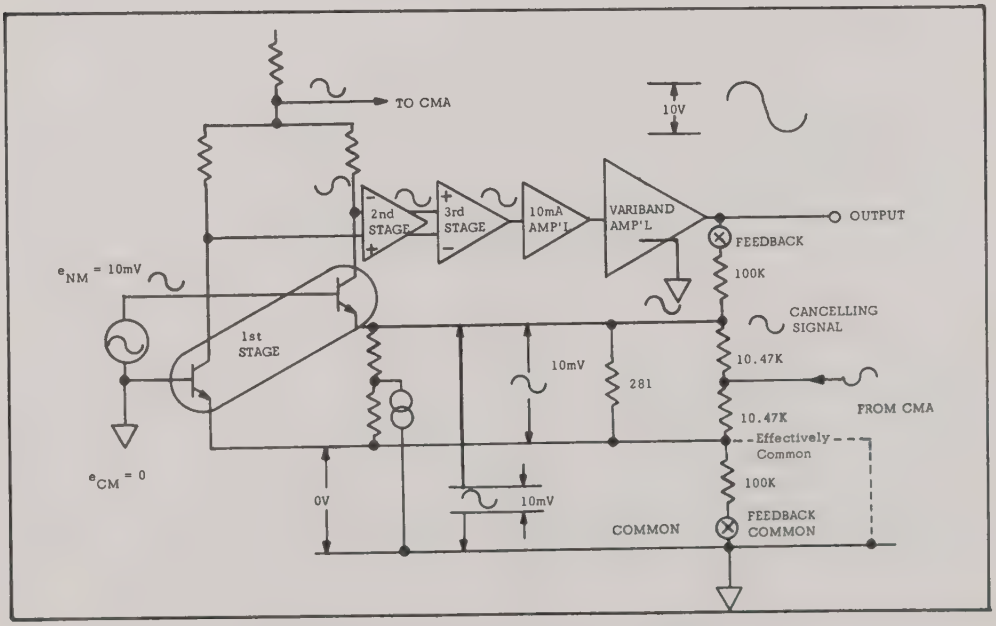


Figure 4.14 - Forced Internal Symmetry

4.7 ADDITIONAL CIRCUIT DETAILS

For ease of explanation, several circuit details were intentionally overlooked. Specifically, the diagrams used to illustrate certain fundamental points inferred a quiescent voltage level of zero at several points that are normally several volts positive or negative with respect to ground. Circuit operation as described is fundamentally accurate except that signal levels are relative to the initial conditions. The static bias condition of the input pair is of particular interest since it is related to input current uncertainty. These stages are initially forward biased and, though the base idling currents are quite low, they would develop an offset voltage if allowed to flow through the external signal source resistance.

To minimize this effect, each input line is connected to a source that shunts this current to the amplifier's internal supplies. An adjustment is provided for each input line, permitting the input current to be periodically rezeroed in the field (R28, R29 in Figure 4.9). To prevent common mode loading, these sources are floated between a constant current generator and the top of the common mode bridge. Since both input leads and the collector supply move together with the common mode potential, the current through the base resistors remains very nearly constant. This infers that the impedance to common potentials is a large magnification of the apparent 5 megohms in each base lead (on the order of 1000 megohms); and also points out that the quiescent base current is virtually undisturbed by common mode potentials.

Another important point is the relationship between the magnitude of the common mode potential and the voltage level at the output of the CMA. If the source of common mode is external, the output of the CMA is 10% greater than the applied voltage; if the source is internal (one-half of the output signal), the output of the CMA is $-E_{out}/20$. This relationship is solely determined by the ratio of the respective feedback resistors.

SECTION 5

CALIBRATION

5.1 TEST EQUIPMENT

(a) OSCILLOSCOPE - Identical X & Y inputs; bandpass, DC-500 kHz; calibrated deflection factors of 1 millivolt to 20 volts per centimeter accurate within 3%; input impedance, 1 megohm paralleled by less than 50 pF.

(b) OSCILLATOR - Frequency range, 5 Hz - 500 kHz; accuracy, ±2%; frequency response, ±1 dB; adjustable output voltage, 160 milliwatts (10 volts) into 600 ohms rated load, 20 volts open circuit.

(c) AC VACUUM TUBE VOLTMETER - Voltage range, 0.1 millivolt to 300 volts; dB range, -72 to +52 dB; frequency range, 10 Hz to 1 MHz accurate within ±2% (50 Hz - 500 kHz); input impedance, 10 megohms paralleled by less than 50 pF.

(d) ATTENUATOR - Attenuation to 120 dB in 1 dB steps; DC to 1 MHz accurate within ±1 dB; power capacity, 5 watts.

(e) DC MILLIVOLTMETER (Optional)

(f) Dana Model 2195 Test Panel (Optional) or Dana Cord Set Model 2801 (P/N 402468). The Dana Model 2195 Amplifier Test Panel provides a convenient means of testing and calibrating Dana amplifiers. The panel requires that only the amplifier, input, output and power inputs be connected with no further reconnections required. All input and output configurations necessary to calibrate or test the amplifier are set up by switches and controls mounted on the panel. The panel is shown in Figure 5.1.

A special adapter cable for 2800 to 2195 is required.

5.2 LISSAJOUS FIGURES FOR COMMON MODE ADJUSTMENTS

The output null of the amplifier is checked with the Lissajour figures shown in Figure 5.2. The adjustments for the quadrature error and amplitude error are mentioned in paragraph 5.3.1. Figure 5.2a shows the amplifier output at null for maximum common mode rejection.

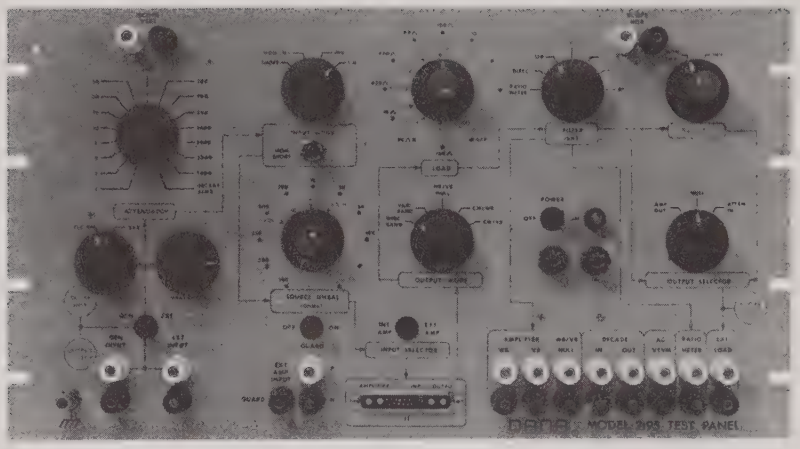


Figure 5.1 - Model 2195 Amplifier Test Panel

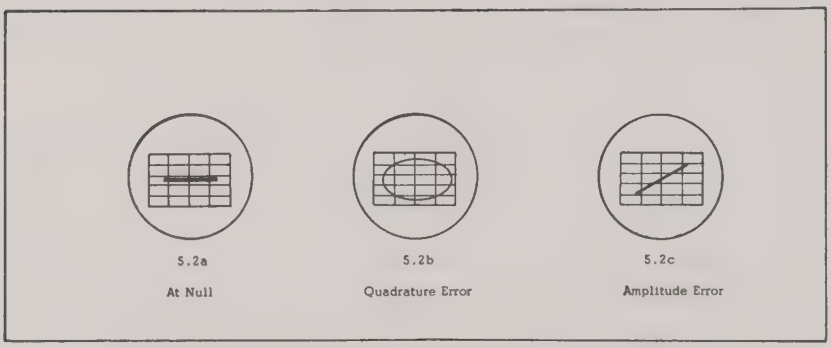


Figure 5.2 - Lissajous Figures

5.3 CALIBRATION PROCEDURES

In addition to the following calibration procedures, certain performance characteristics should be checked periodically and internal adjustments made as required. These measurements are described in Section 5.4. The procedure below should be performed in the order listed.

5.3.1 Common Mode Adjustment

NOTE: Common mode potentials appear between the guard box and chassis; therefore, an insulated screwdriver or adjustment tool (J.F.D. Adjustment Tool 5284) should be used to make the calibration adjustments of the input amplifier.

The amplifier has four controls that affect common mode rejection by adjusting the symmetry of the input circuit. R43 and R10 compensate for resistive unbalance. C5 and C15 adjusts the capacitive symmetry. Physical location of the four components is shown in Figure 5.3.

The V1 and V3 gain options quadrature error and amplitude error are adjusted by adjusting the following components:

Capacitor C15 - quadrature error
Potentiometer R43 - amplitude error

The V2 option has the above adjustments when the Multiplier switch is in the X1 position. Another set of adjustments calibrates the quadrature and amplitude error for the X.01 Multiplier switch position. These adjustments are:

Capacitor C5 - quadrature error
Potentiometer R10 - amplitude error

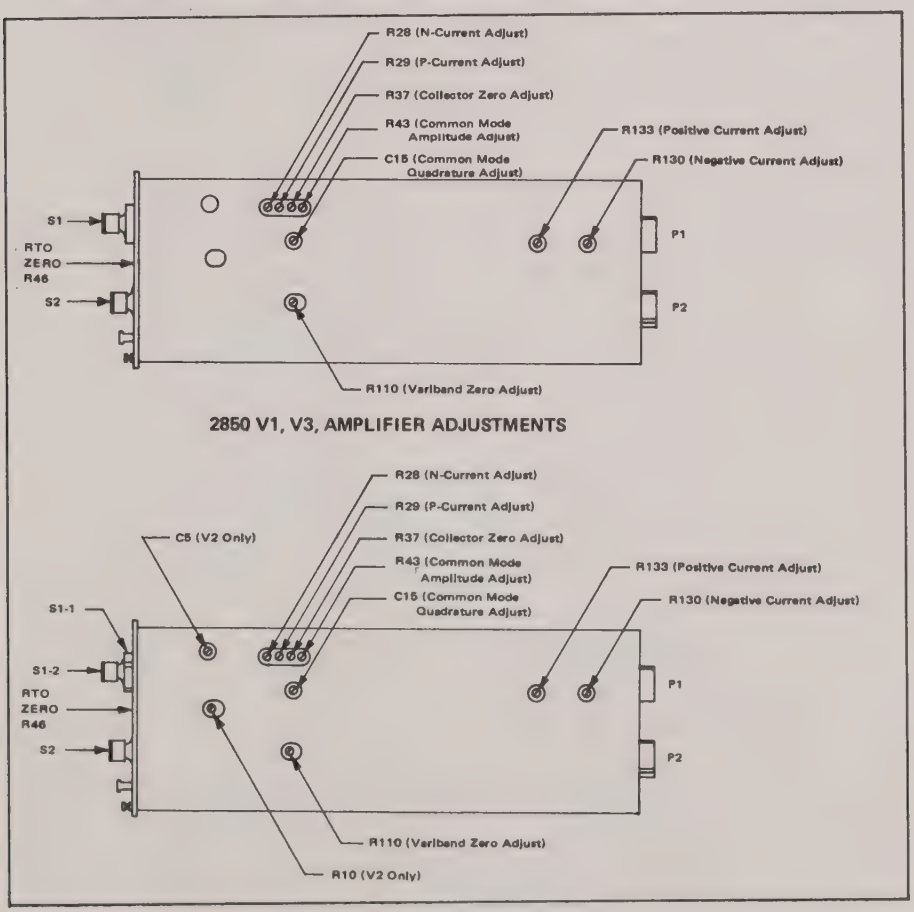


Figure 5.3 2850-Amplifier Adjustments

Common mode adjustment procedures are as follows:

(1) For V1 attenuator option:

(a) Connect inputs P(P1-8), N(P1-4), and guard (P1-7) to the high side of a signal generator, returning the low side to output common (P2-1).

(b) Connect the signal generator to the X-axis (horizontal) of an oscilloscope with the X-axis sensitivity set to 5 V/cm.

(c) Connect the amplifiers output (P2-5) to the Y-axis (vertical) of the oscilloscope through a single pole, low pass filter consisting of a 16K resistor and a 0.01 microfarad capacitor. Set the sensitivity of the Y-axis to 10 mV/cm. (See figure 5.4).

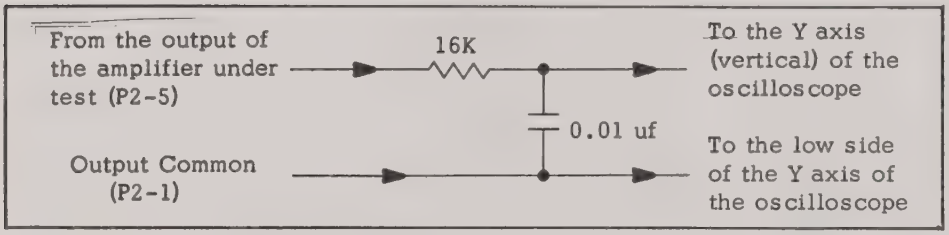

From the output of the amplifier under test (P2-5)
16K
To the Y axis (vertical) of the oscilloscope
0.01 uf
Output Common (P2-1)
To the low side of the Y axis of the oscilloscope

Figure 5.4 - Single-pole low pass filter

(d) Place the gain switch (S1) in the 1000 position, and the variband switch (S2) in the wideband position.

(e) Set the signal generator to 20 volts (P-P) at 60 Hz.

(f) Adjust the amplitude error potentiometer (R43) for minimum amplitude error as shown in figure 5.2c.

(g) Adjust the quadrature error trimmer (C15) for minimum quadrature error as shown in figure 5.2b.

(h) Adjust both R43 and C15 for a straight line as shown in figure 5.2a.

(2) For V2 attenuator option:

(a) Complete steps 5.3.1(1) (a) through (h) before continuing the Common Mode Adjustment for V2 attenuator option.

(b) Place the multiplier switch to the X.01 position.

(c) Adjust the amplitude error potentiometer (R10) for minimum amplitude error as shown in figure 5.2c.

(d) Adjust the quadrature error trimmer (C5) for minimum quadrature error as shown in figure 5.2b.

(e) Adjust both (R10) and (C5) for as near as possible a straight line as shown in figure 5.2a.

(3) For V3 attenuator option:

(a) For V3 attenuator option, complete steps, 5.3.1 (a) through (h). Be sure the gain switch (S1) is in the 1000 position, and not the 5000 position. All common mode adjustments and measurements are performed in the gain of 1000.

5.3.2 Collector Zero Adjustment (RTI)

In addition to the operational zero (RTO) adjustment on the front panel, the amplifier is equipped with an internal RTI collector zero adjustment (R37). Procedure for making the adjustment is as follows:

(a) Connect the amplifier inputs P(P1-8), N(P1-4), and guard (P1-7) to output common (P2-1).

(b) Connect an oscilloscope or millivoltmeter to output (P2-5) and common (P2-1).

(c) Set the amplifier gain switch to the gain position (20 for V1, V2 options; 100 for V3 option); set (V2 options only) the multiplier in the X1 position.

(d) Adjust the front panel RTO zero adjustment (R46) for minimum reading on the oscilloscope or millivoltmeter. Record any residual offset.

(e) Set the amplifier gain switch to the 1000 position for gain options V1, V2, and V3 option.

(f) Adjust the internal RTI collector zero adjustment (R37) for the same offset recorded in step (d).

(g) Repeat steps (d), (e) and (f) until the output remains the same on both the higher and the lowest gain positions.

(h) Set the multiplier switch (V2 options only) in the X.01 position.

(i) Set the gain switch to the 1000 position.

(j) Adjust the "N" current adjustment (R28) for the same offset recorded in step (d). The "N" current adjustment (R28) also adjusts the X01 multiplier RTI zero adjust.

5.3.3 Input Current Adjustment

This adjustment minimizes current flow through the input terminals. For most accurate adjustment, the following procedures should be performed after the collector zero adjustment.

(a) Set the amplifier gain switch to the gain of 1000 for V1, V2, and V3 options. Set the multiplier switch (V2 option only) in the X1 position.

(b) Connect a 1K ohm resistor to the P input lead P(P1-8). Connect another 1K ohm resistor to the N input lead N(P1-4). Connect the two 1K ohm resistors and guard (P1-7) to output common (P2-1). (See Figure 5.5)

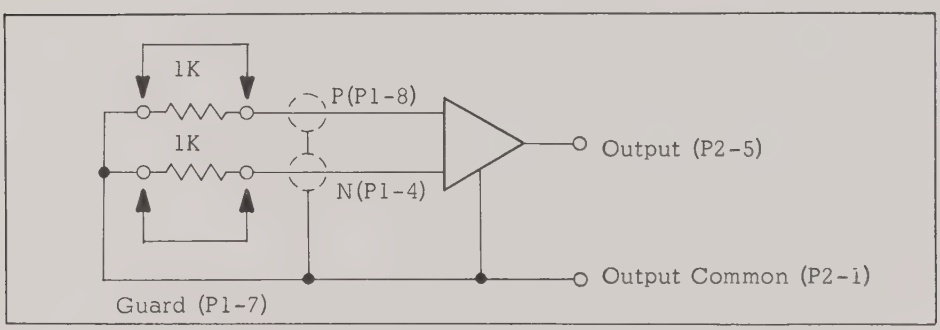


Figure 5.5 - Input Lead Connections

(c) Connect the oscilloscope to output (P2-5) and common (P2-1). Set the vertical deflection to 5 mV/cm.

(d) Short out the 1K ohm resistors in step 5.3.3b. Record the output offset as indicated by the oscilloscope. (See figure 5.5)

(e) Remove the short across the 1K ohm resistor in series with the N lead (P1-4). Adjust R28, the N current control for the same offset recorded in step 5.3.3d. Short out the 1K ohm resistor on the N lead.

(f) Adjust R37 RTI collector zero for the same offset as step 5.3.3d.

(g) Remove the short across the 1K ohm resistor in series with the P lead (P1-8). Adjust R29 P-current adjust; for the same offset as in step 5.3.3d. Short out the 1K ohm resistor on the N lead.

(h) Repeat step 5.3.3f.

(i) Repeat steps (e), (f) and (g) until there is no offset between the P or N leads with or without the 1K ohm resistors in series. All three voltages should be the same offset within 1 mv of each other.

(j) Set the multiplier switch (V2 only) to the X01 position. Adjust R28 N-current adjustment to the same offset as in step 5.3.3d.

5.3.4 Output Zero Adjustment

This adjustment sets the zero of the Output Amplifier by means of the ZERO adjustment on the front panel.

1. Connect input terminals N(P1-4) and P(P1-8) to output common (P2-1). Connect this point to ground.

2. Connect an oscilloscope across the output (P2-5) and common (P2-1).

3. Vary the ZERO adjustment (on front panel) for minimum reading on oscilloscope. Note this voltage for further reference. (This voltage represents residual offset).

5.3.5 Output Current Limit Adjustment

Although the output short circuit current is set at Dana for ± 150 ma, it may be desirable to limit the output current to a lesser value to afford the recording device protection. Potentiometers R91, 92, located on the printed circuit board, vary the output short circuit current from 60 ma to 150 ma. A voltage limit at the output of ± 13V DC or peak AC provides an additional degree of protection to the recording device.

To set the output current for 100 milliamperes, follow the steps below:

(1) Connect a 10 volt power supply, a 10 ohm 1/2 watt load resistor, and a DC voltmeter as shown in Figure 5.6. Connect battery as in position "A".

(2) Adjust R92 until the voltmeter reads 1.0 volts ± 10%.

(3) Connect the battery as in position "B".

(4) Adjust R91 until the voltmeter reads 1.0 volts ± 10%.

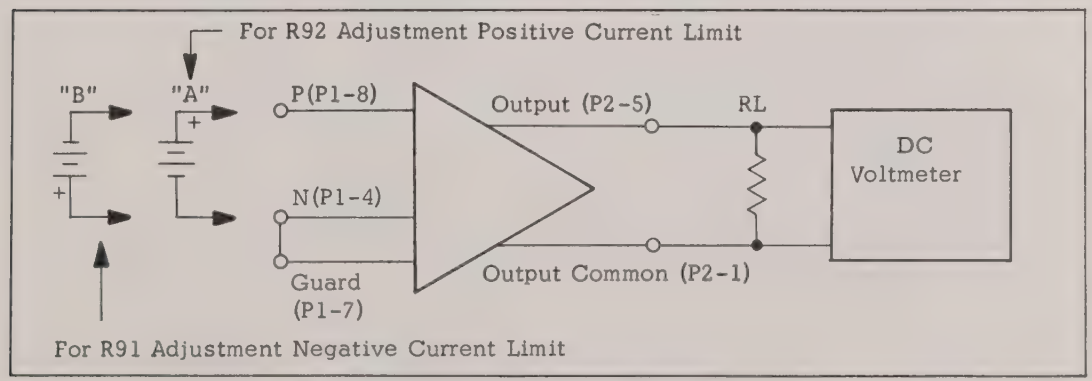


Figure 5.6 - Test Setup for Current Limits

5.4 TESTS OF AMPLIFIER CHARACTERISTICS

The following measurements check basic amplifier operating characteristics -- such as gain, bandpass, etc.

5.4.1 DC Gain Measurement

1. Connect test setup as shown in Figure 5.7. (The signal source need not be particularly accurate or stable, but the voltage divider must be extremely accurate. The null detector must be isolated and resolve less than 1 mV).
2. Set DC voltage source at 10 volts.
3. Adjust voltage divider so that there is no change in null detector indication when the input polarity is reversed by the reversing switch. Note ratio of voltage divider setting. Calculate gain as follows:

$$K = \frac{1}{h}$$

where K = amplifier gain
h = ratio of voltage output to input of divider.

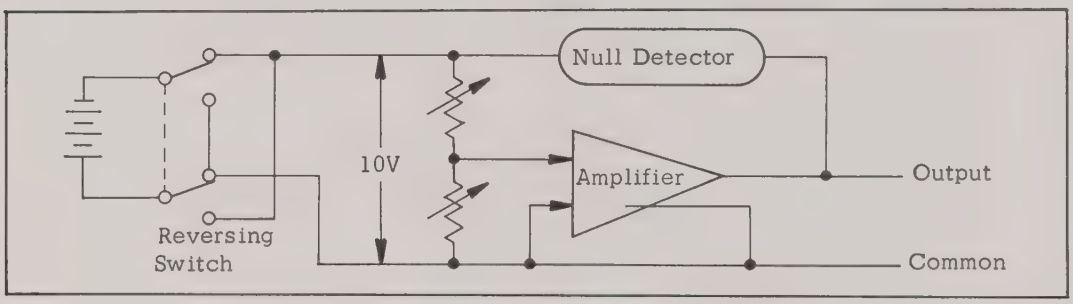


Figure 5.7 - Test Setup, DC Gain Measurement

5.4.2 Linearity Measurement

Ideally, gain should be independent of the magnitude of the output voltage from minus full scale to plus full scale. Since the Dana Amplifier's departure from this ideal is small, the null balance method of the gain measurement is again used. Linearity can be measured immediately after the DC gain measurement (see Figure 5.7). The test setup shall remain the same except that a variable DC voltage is required.

Steps 1 and 2 are followed as for DC gain Measurement (5.4.1). The input voltage is then varied from minus full scale to plus full scale, and the peak reading of the null detector recorded. The linearity in percentage can be calculated as follows:

$$\frac{\text{Peak Null Detector Reading (Volts)} \times 100}{\text{Full Scale (10 Volts)}}$$

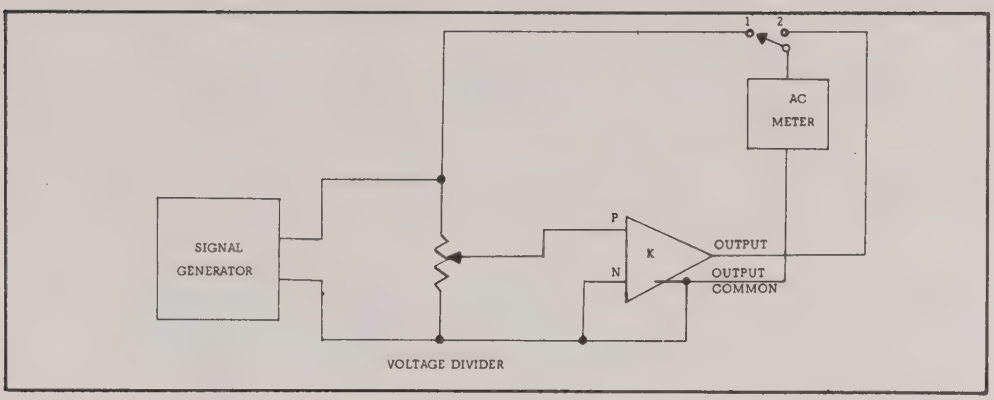


Figure 5.8 - Test Setup, AC Gain Measurement

5.4.3 AC Gain Measurement

The technique used for DC gain measurement can be extended to AC if the phase lag in the amplifier is compensated and a suitable null detector is used. If these types of measurements are anticipated, a special transformer and phase correction network may be procured from Dana; however, in general, a simpler and more direct method is described below:

1. Connect test setup as shown in Figure 5.8. (The divider should be of sufficiently low impedance to prevent errors due to source resistance. The output meter should be a good quality AC voltmeter having a mirrored scale and at least 100 minor divisions).

2. Place the monitor switch to position 1 and set the signal generator to an output of approximately 7 volts RMS at 60 Hz.

3. Select a minor division on the meter's best scale (maximum resolution and legibility) and adjust the output of the signal generator very carefully to place the needle of the meter directly on this marker. Use the mirror to avoid parallax.

4. Set the monitor switch to position 2 and adjust the voltage divider for exactly the same reading established in step 2.

5. Carefully observing the meter, move the monitor switch alternately between positions 1 and 2 to ensure that the reading is exactly the same in both positions.

6. Compute the gain of the amplifier by taking the reciprocal of the ratio set up on the voltage divider.

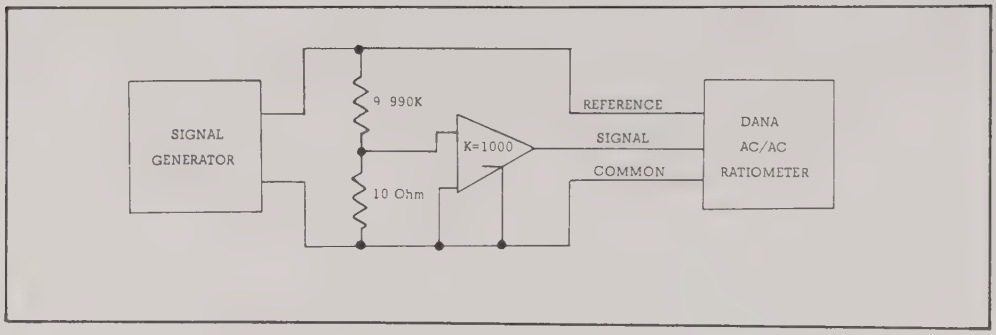


Figure 5.9 - Test Setup, High Frequency Linearity

5.4.4 Bandwidth Measurement

Bandwidth is measured by determining the difference in AC gain at low and at high frequencies. Since there is seldom a need to define bandwidth with extreme accuracy, the measurement procedures may be shortened as follows:

1. Use same test setup as for AC Gain Measurement, Figure 5.8.
2. Follow steps (1) through (4) for AC Gain Measurement with the signal generator set to 60 Hz.
3. Increase the frequency to 20kHz (gains 20-1000; 10kHz for gains below 20 or above 1000). Record the difference in readings between switch positions 1 and 2. If the meter has 100 minor divisions, each division represents approximately 1.4% of full scale.

In making the above measurement, it must be remembered that the bandwidth specifications apply for source impedances up to 350 ohms. When checking bandwidth make certain this value is not exceeded. If a low impedance divider is not available, it may be necessary to improvise one.

5.4.5 High Frequency Linearity

Linearity is determined by the following equation:

$$\text{Linearity (in \%)} = 100 \frac{E_{out} - KE_{in}}{E_{out\ (full\ scale)}}$$

To measure high frequency linearity, an extremely accurate AC/AC ratiometer is recommended such as the Dana Model 5400/060 or 5740. The measurement procedures are listed below:

1. Connect test setup as shown in Figure 5.9. Set the signal generator to approximately 7 volts RMS at 60 Hz. Set amplifier GAIN to 1000.

2. Trim the input divider and/or the amplifier vernier control until the absolute ratio is 0.99990 (displayed on ratiometer as 9.9990). This reading indicates a slight gain error; however, this is not important to the linearity measurement and allows the latter to be made with greater resolution.

3. Leaving all other adjustments set, increase the signal generator frequency to 2 kHz and observe the new reading on the ratiometer.

4. Compute linearity as follows:

$$\text{Linearity in \%} = \frac{\text{Reading 1} - \text{Reading 2}}{1000}$$

If no range changes are involved, the result can be more quickly computed by allowing 0.001% for each digit of difference.

SECTION 6

TROUBLESHOOTING

6.1 GENERAL

Conventional instrumentation amplifiers are often difficult to troubleshoot, since the average malfunctions cause abnormal readings or signal levels to appear throughout the loop. By comparison, the Dana Amplifier is far easier to service since the various direct-coupled circuits can be readily isolated and inspected independently.

6.2 DANA REPAIR AND SERVICE POLICY

Details of Dana's repair and service policy may be found in the Dana Warranty at the rear of the manual. Items for repair should include a copy of the Dana return form describing the reason for return. Units not accompanied by this information must be held without action pending receipt of this information. A copy of this Repair/Return form is included at the rear of this manual. Additional copies may be obtained from Dana Laboratories or from Dana Sales representatives.

6.3 TROUBLESHOOTING GUIDES

Component failures may cause bias points to shift and loop gain to change such that the output voltage will move from near zero volts to a large positive or negative d-c voltage level. These levels are greater than ± 12 volts and are called "positive lockup" and "negative lockup". Three malfunctions in the amplifier can cause output lockup. These are:

- Open or short circuit
- Defective component
- Drastic change in component characteristics

The troubleshooting guides help to isolate sections of the amplifier where the malfunction may exist. The sections can be isolated without having to break or disconnect any of the loops in the amplifier.

The step-by-step troubleshooting procedure verifies that there are no open or shorted components and that the current generators are supplying the proper currents to the circuits.

A preliminary check is to be made prior to using the troubleshooting guides. Short the P input (P1-8), N input (P1-4), and Guard (P1-7) together and connect these leads to output common (P2-1). The output voltage (P2-5) with respect to common should be near zero (zero ±250 millivolt). If the output voltage is near zero, proceed to the calibration section of this manual. If the output voltage is greater than plus or minus 12 volts, the output is at lockup. Apply the troubleshooting guides in the following sequence:

1. Power Supply
2. Output Amplifier
3. 10MA Amplifier
4. Normal Mode Amplifier
5. Common Mode Amplifier
6. Feedback Network

> CAUTION
>
> The guides assume that the troubleshooter is experienced in troubleshooting solid state circuits. Non-standard practices can cause more damage to the amplifier.

Reference is made to the schematic number and assembly number where the circuit designators are located. These numbers appear at the bottom of the troubleshooting guide.

Unless the troubleshooting guide indicates otherwise, the output voltage is monitored at P2-5 (output) and P2-1 (output common).

6.4 TROUBLESHOOTING EQUIPMENT

All of the transistors in the amplifier can be checked in the circuit. The only exception is the output transistor Q15 of the Common Mode Amplifier, see schematic 430440). Diode CR12 is across the collector to emitter leads of transistor Q15.

The following equipments are needed to troubleshoot the amplifier:

- A Simpson VOM (volt-ohmmeter) Model 260 or equivalent, can be used to check the forward and reverse resistances of the semiconductors. Disconnect the AC power prior to making these measurements.

- A 2000 ohms, 1/4 watt, carbon resistor.
- An oscilloscope or a voltmeter capable of measuring positive and negative voltages without manually changing the polarity for monitoring the output voltage of the amplifier.
- A precision ohmmeter. The tolerance value of most precision resistors in the amplifier is 0.1%.
- Dana Cord Set - Part Number 402468.

6.5 COMPONENT REPLACEMENT

Defective components should be replaced with components identical to the original component. Precision wirewound resistors with 0.1% tolerances should be replaced with wirewound resistors of the same tolerance value. The characteristics of the components are critical for temperature stability, zero stability, and gain stability.

The first stage dual (Q2) and the second stage dual (Q5) of the normal mode amplifier should be ordered from the factory. The first stage dual transistor is part of a kit along with four precision resistors. This stage should be replaced as a unit. The Dana part number for the first stage kit is 400708. The kit consists of a selected dual transistor (Q2) and selected wirewound resistors R38, R39, R45, and R47.

The Dana part number for the second stage dual (Q5) of the normal mode amplifier is 201285.

Dana recommends that the components be ordered from the Dana service department. Specify the part and Dana part number for the defective component.

The amplifier should be recalibrated after replacing components. Refer to the calibration procedures in Section 5.

6.6 AMPLIFIER DISASSEMBLY

(1) Remove the eight number 6 Phillips Flat-Head screws from the aluminum support (right-hand side of the amplifier as viewed from the front panel).

(2) Slide the dust cover (left-hand side) to the rear of the amplifier. Remove the dust cover from the aluminum support. Refer to figure 6.1a.

(3) To remove the aluminum support, remove six number 4, Phillips pan-head screws and lock washers. These screws hold the circuit board assembly to the aluminum support. Do not remove the six number 2, Phillips pan-head screws and lock washers at this time. Three are located at the front of the circuit board and the remaining three are at

the back of the circuit board. Slide the aluminum support to the rear of the amplifier and remove. Do not allow the weight of the aluminum support to bend the circuit board assembly as breakage may occur. Refer to figure 6.1b.

(4) The guard box encloses the Input Amplifier and Feedback Network. To remove the guard box cover, remove two, number 4, Phillips pan-head screws at the top of the cover and lift the cover from the guard box. The guard box is shown in Figure 6.1c.

(5) The etched ~~circuit side~~ of the Input Amplifier is electrically guarded by a fiberglass guard plate. The guard plate is held to two standoffs by two, number 4, Phillips flat-head screws. Remove the guard plate to probe the etched circuit side of the Input Amplifier.

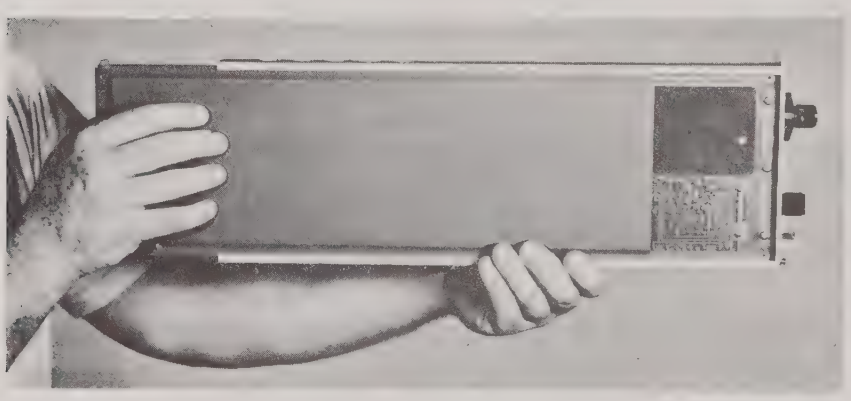


Figure 6.1a

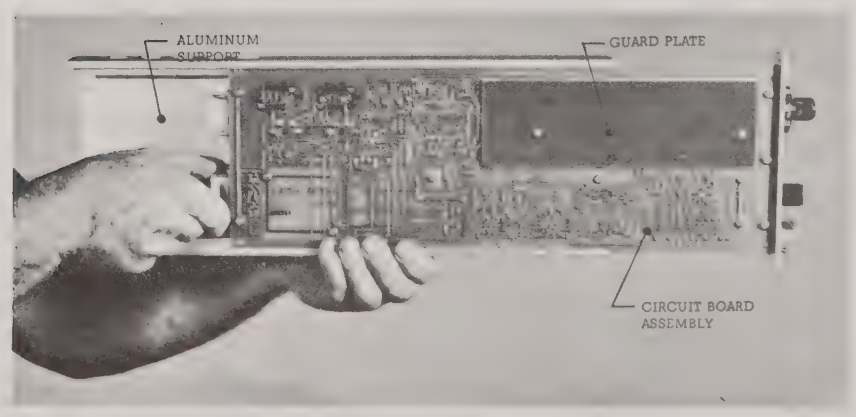


Figure 6.1b

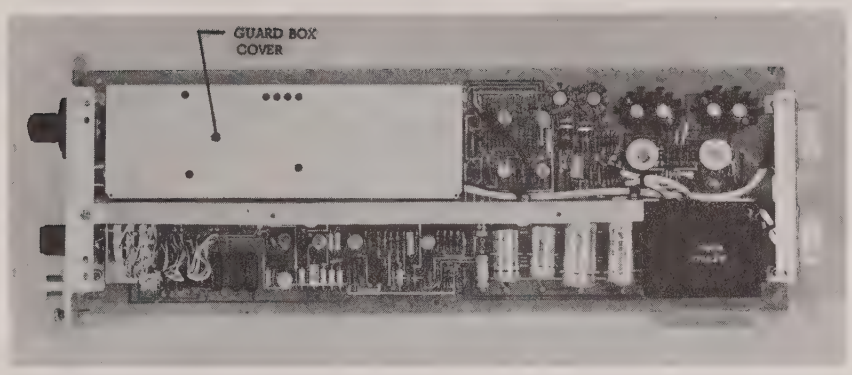


Figure 6.1c

TROUBLESHOOTING GUIDES

Power Supply I

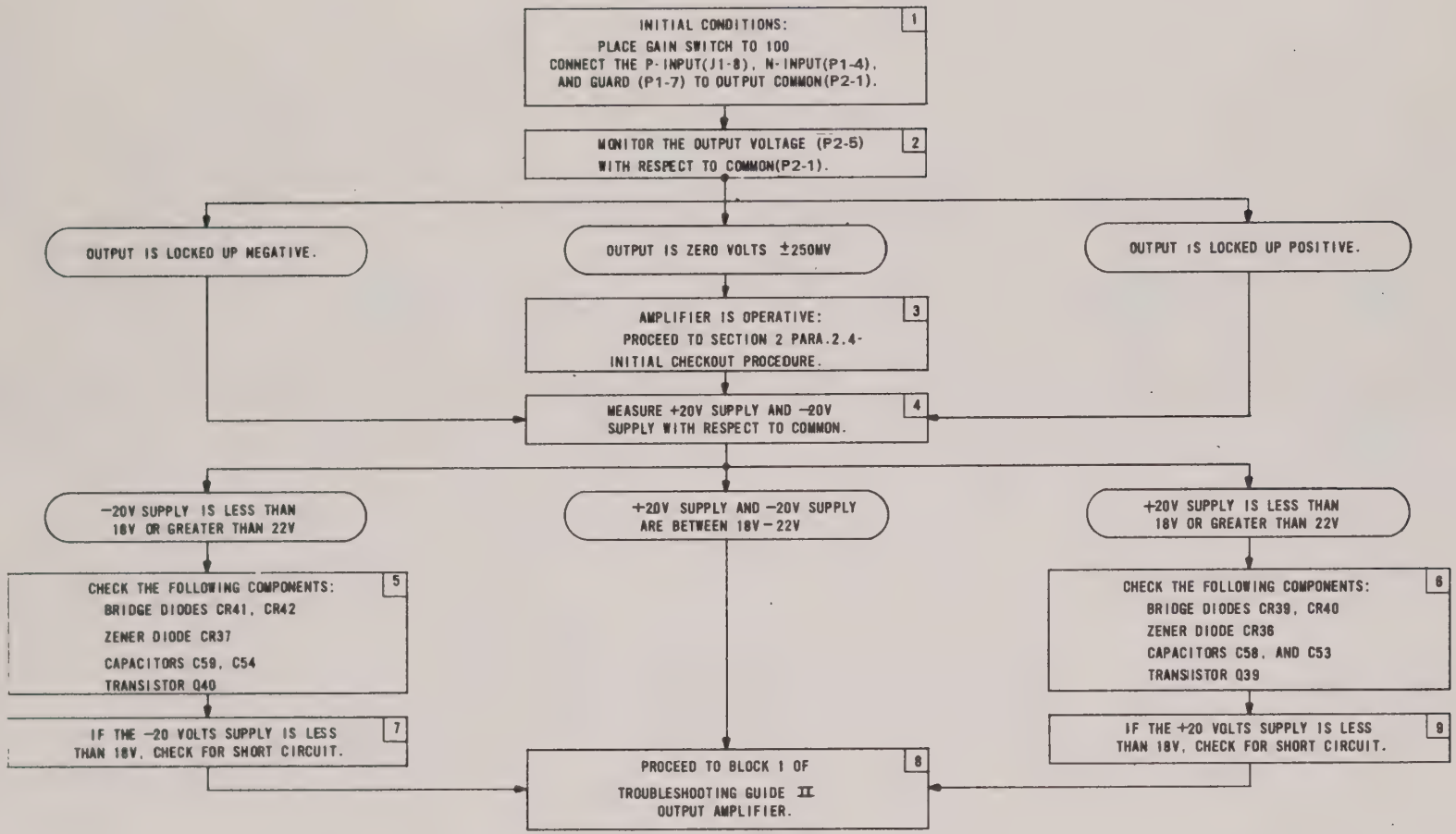
Output Amplifier II

10 MA Amplifier III

Normal Mode Amplifier (2 sheets) IV

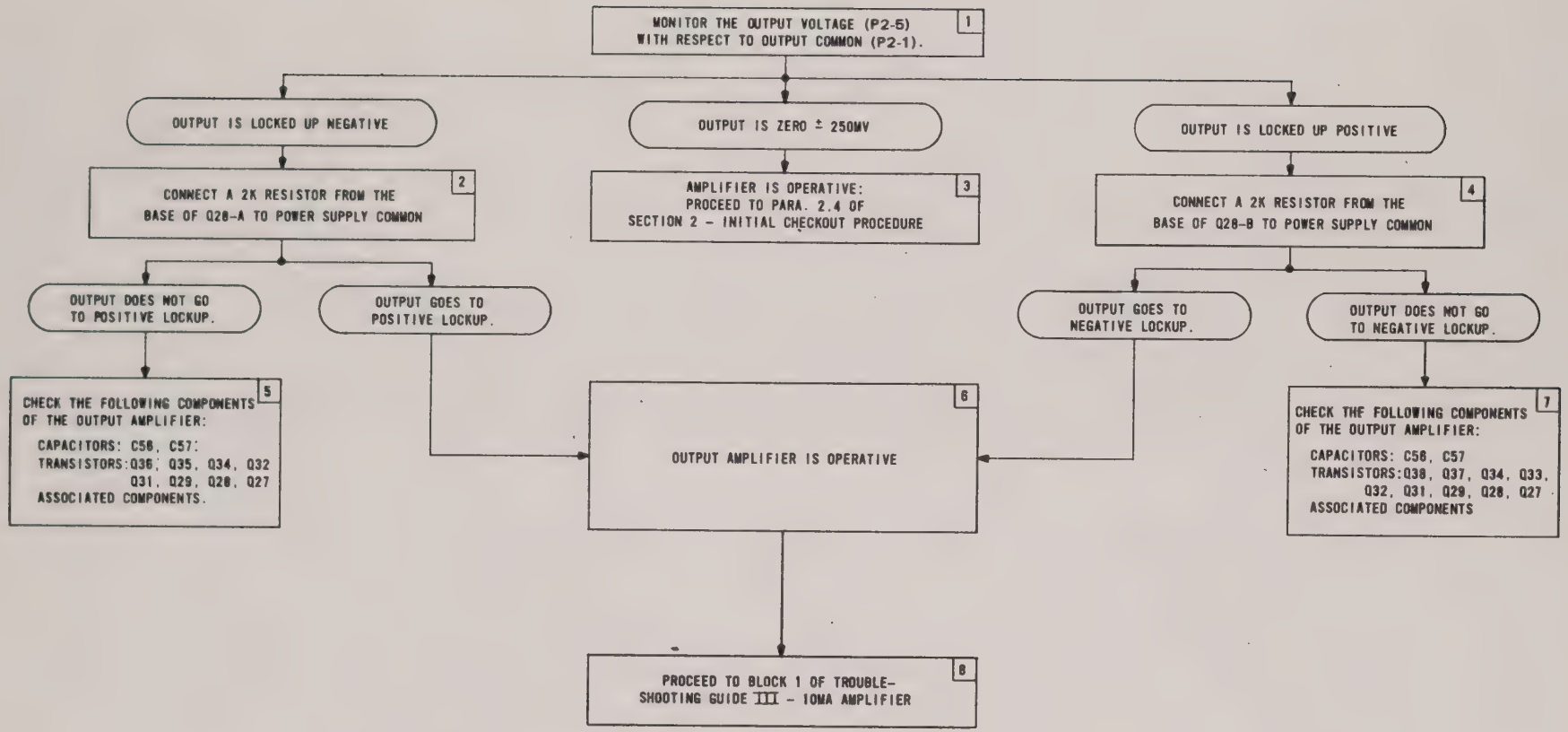
Common Mode Amplifier V

Feedback Network VI



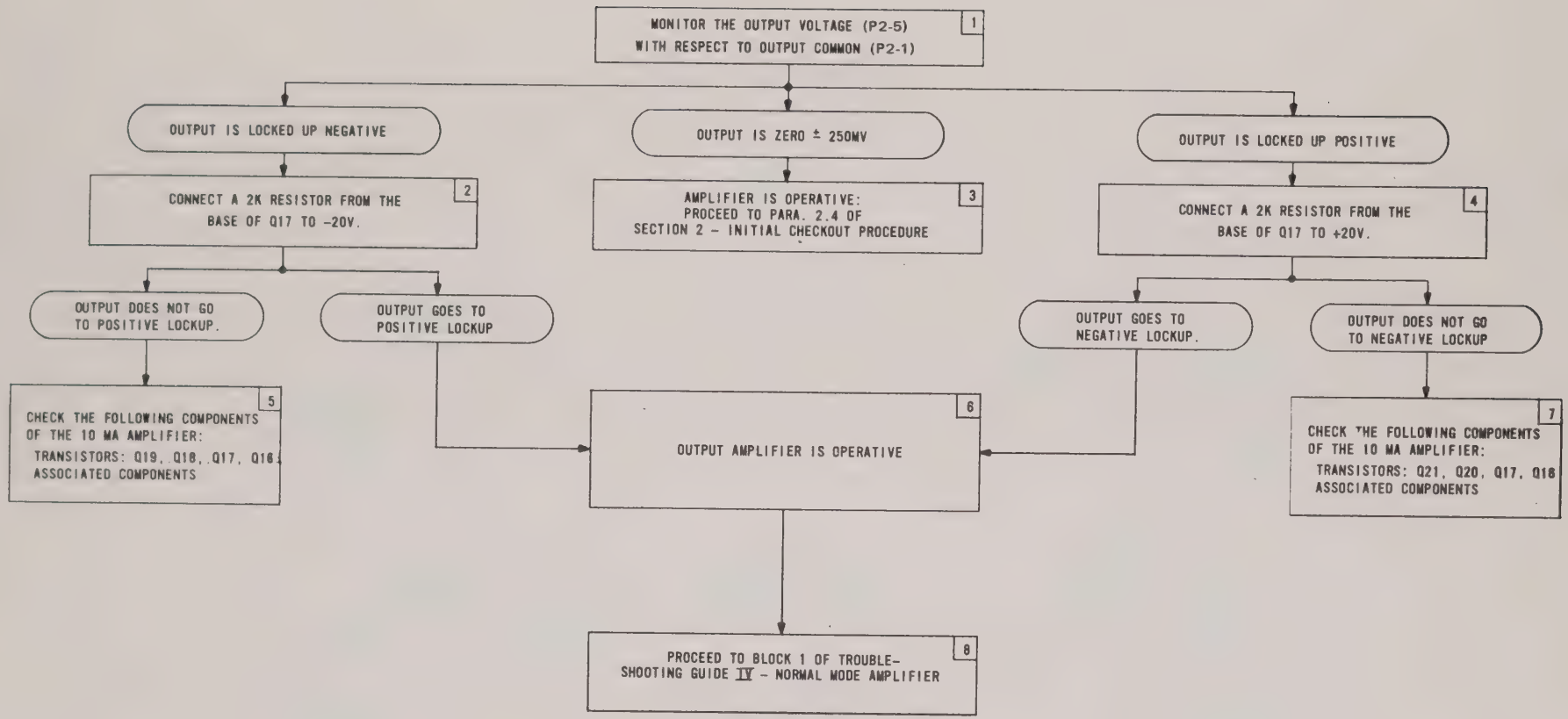
TROUBLESHOOTING GUIDE I
SHEET 1 OF 1
MODEL 2850-POWER SUPPLY

OPTION	SCHEMATIC	ASSEMBLY
V1	430440	402310, 402312
V2	430441	402311, 402312
V3	430630	402392, 402312


MONITOR THE OUTPUT VOLTAGE (P2-5) WITH RESPECT TO OUTPUT COMMON (P2-1). 1
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO ± 250MV
OUTPUT IS LOCKED UP POSITIVE
CONNECT A 2K RESISTOR FROM THE BASE OF Q28-A TO POWER SUPPLY COMMON 2
AMPLIFIER IS OPERATIVE: PROCEED TO PARA. 2.4 OF SECTION 2 - INITIAL CHECKOUT PROCEDURE 3
CONNECT A 2K RESISTOR FROM THE BASE OF Q28-B TO POWER SUPPLY COMMON 4
OUTPUT DOES NOT GO TO POSITIVE LOCKUP.
OUTPUT GOES TO POSITIVE LOCKUP.
OUTPUT GOES TO NEGATIVE LOCKUP.
OUTPUT DOES NOT GO TO NEGATIVE LOCKUP.
CHECK THE FOLLOWING COMPONENTS OF THE OUTPUT AMPLIFIER: 5
CAPACITORS: C56, C57:
TRANSISTORS: Q36, Q35, Q34, Q32 Q31, Q29, Q28, Q27
ASSOCIATED COMPONENTS.
OUTPUT AMPLIFIER IS OPERATIVE 6
CHECK THE FOLLOWING COMPONENTS OF THE OUTPUT AMPLIFIER: 7
CAPACITORS: C56, C57
TRANSISTORS: Q38, Q37, Q34, Q33, Q32, Q31, Q29, Q28, Q27
ASSOCIATED COMPONENTS
PROCEED TO BLOCK 1 OF TROUBLE-SHOOTING GUIDE III - 10MA AMPLIFIER 8

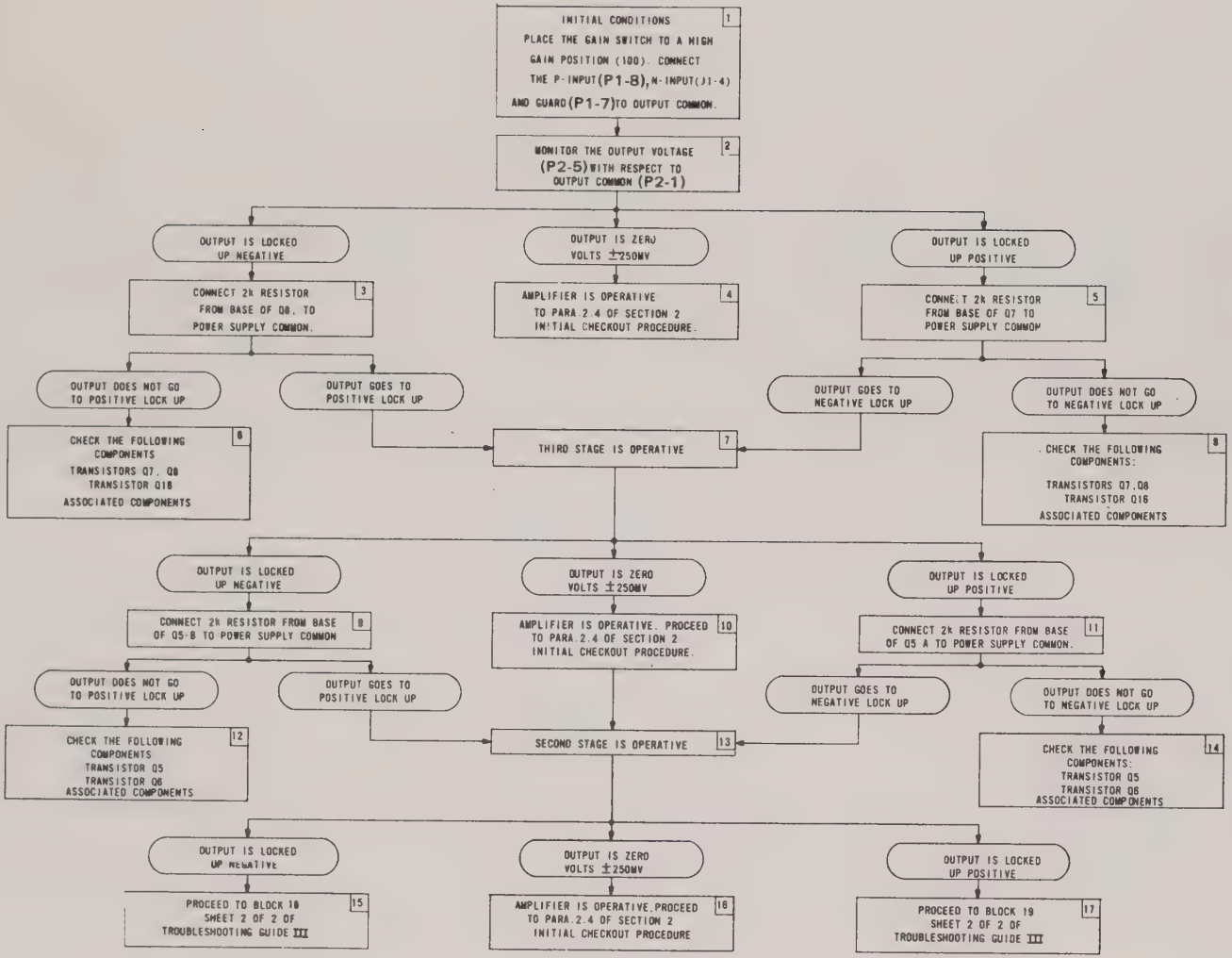
TROUBLESHOOTING GUIDE II
SHEET 1 OF 1
MODEL 2850 - 100MA OUTPUT AMPLIFIER

OPTION	SCHEMATIC	ASSEMBLY
V1	430440	402310, 402312
V2	430441	402311, 402312
V3	430830	402392, 402312



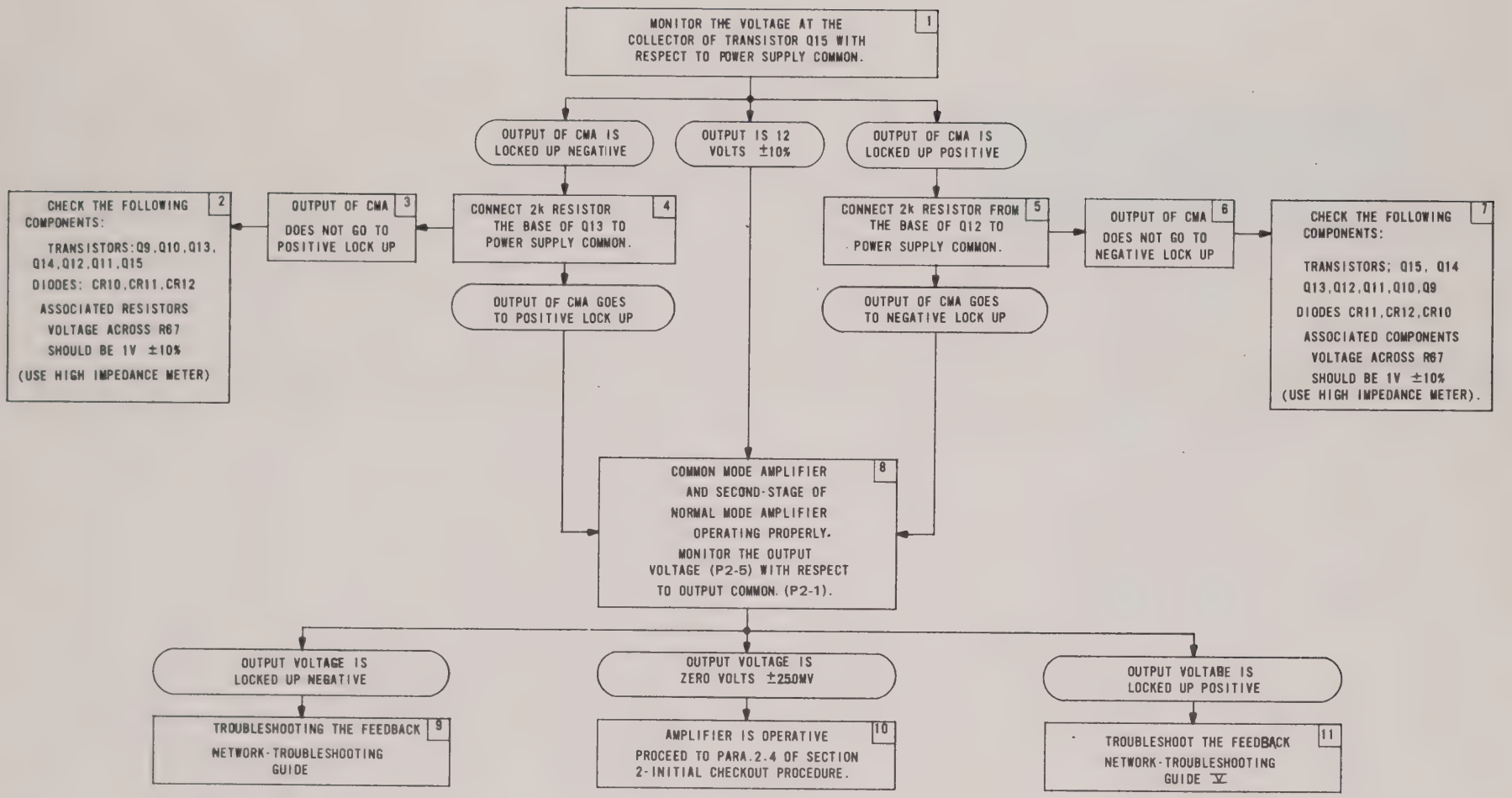
TROUBLESHOOTING GUIDE III
SHEET 1 OF 1
MODEL 2850 - 10MA AMPLIFIER

OPTION	SCHEMATIC	ASSEMBLY
V1	430440	402310, 402312
V2	430441	402311, 402312
V3	430630	402392, 402312


1
INITIAL CONDITIONS
PLACE THE GAIN SWITCH TO A HIGH GAIN POSITION (100). CONNECT THE P-INPUT(P1-8), N-INPUT(J1-4) AND GUARD(P1-7)TO OUTPUT COMMON.
2
MONITOR THE OUTPUT VOLTAGE (P2-5)WITH RESPECT TO OUTPUT COMMON (P2-1)
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO VOLTS ±250MV
OUTPUT IS LOCKED UP POSITIVE
3
CONNECT 2k RESISTOR FROM BASE OF Q8, TO POWER SUPPLY COMMON.
4
AMPLIFIER IS OPERATIVE TO PARA.2.4 OF SECTION 2 INITIAL CHECKOUT PROCEDURE.
5
CONNECT 2k RESISTOR FROM BASE OF Q7 TO POWER SUPPLY COMMON
OUTPUT DOES NOT GO TO POSITIVE LOCK UP
OUTPUT GOES TO POSITIVE LOCK UP
OUTPUT GOES TO NEGATIVE LOCK UP
OUTPUT DOES NOT GO TO NEGATIVE LOCK UP
6
CHECK THE FOLLOWING COMPONENTS
TRANSISTORS Q7, Q8
TRANSISTOR Q18
ASSOCIATED COMPONENTS
7
THIRD STAGE IS OPERATIVE
8
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS Q7,Q8
TRANSISTOR Q16
ASSOCIATED COMPONENTS
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO VOLTS ±250MV
OUTPUT IS LOCKED UP POSITIVE
9
CONNECT 2k RESISTOR FROM BASE OF Q5-B TO POWER SUPPLY COMMON
10
AMPLIFIER IS OPERATIVE. PROCEED TO PARA.2.4 OF SECTION 2 INITIAL CHECKOUT PROCEDURE.
11
CONNECT 2k RESISTOR FROM BASE OF Q5 A TO POWER SUPPLY COMMON.
OUTPUT DOES NOT GO TO POSITIVE LOCK UP
OUTPUT GOES TO POSITIVE LOCK UP
OUTPUT GOES TO NEGATIVE LOCK UP
OUTPUT DOES NOT GO TO NEGATIVE LOCK UP
12
CHECK THE FOLLOWING COMPONENTS
TRANSISTOR Q5
TRANSISTOR Q6
ASSOCIATED COMPONENTS
13
SECOND STAGE IS OPERATIVE
14
CHECK THE FOLLOWING COMPONENTS:
TRANSISTOR Q5
TRANSISTOR Q6
ASSOCIATED COMPONENTS
OUTPUT IS LOCKED UP NEGATIVE
OUTPUT IS ZERO VOLTS ±250MV
OUTPUT IS LOCKED UP POSITIVE
15
PROCEED TO BLOCK 18 SHEET 2 OF 2 OF TROUBLESHOOTING GUIDE III
16
AMPLIFIER IS OPERATIVE.PROCEED TO PARA.2.4 OF SECTION 2 INITIAL CHECKOUT PROCEDURE
17
PROCEED TO BLOCK 19 SHEET 2 OF 2 OF TROUBLESHOOTING GUIDE III

TROUBLESHOOTING GUIDE IV
SHEET 1 OF 2
MODEL 2850-NORMAL MODE AMPLIFIER

OPTION	SCHEMATIC	ASSEMBLY
V1	430440	402310, 402312
V2	430441	402311, 402312
V3	430830	402392, 402312

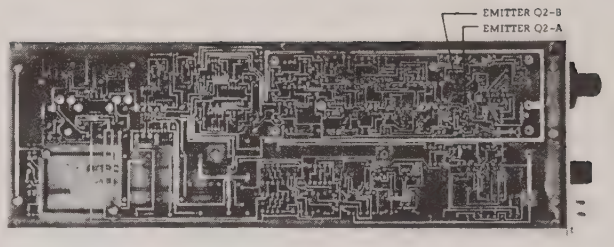

1
MONITOR THE VOLTAGE AT THE COLLECTOR OF TRANSISTOR Q15 WITH RESPECT TO POWER SUPPLY COMMON.
OUTPUT OF CMA IS LOCKED UP NEGATIIVE
OUTPUT IS 12 VOLTS ±10%
OUTPUT OF CMA IS LOCKED UP POSITIVE
2
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS:Q9,Q10,Q13, Q14,Q12,Q11,Q15
DIODES: CR10,CR11,CR12
ASSOCIATED RESISTORS
VOLTAGE ACROSS R67
SHOULD BE 1V ±10%
(USE HIGH IMPEDANCE METER)
3
OUTPUT OF CMA
DOES NOT GO TO POSITIVE LOCK UP
4
CONNECT 2k RESISTOR THE BASE OF Q13 TO POWER SUPPLY COMMON.
OUTPUT OF CMA GOES TO POSITIVE LOCK UP
5
CONNECT 2k RESISTOR FROM THE BASE OF Q12 TO POWER SUPPLY COMMON.
OUTPUT OF CMA GOES TO NEGATIVE LOCK UP
6
OUTPUT OF CMA
DOES NOT GO TO NEGATIVE LOCK UP
7
CHECK THE FOLLOWING COMPONENTS:
TRANSISTORS; Q15, Q14 Q13,Q12,Q11,Q10,Q9
DIODES CR11,CR12,CR10
ASSOCIATED COMPONENTS
VOLTAGE ACROSS R67
SHOULD BE 1V ±10%
(USE HIGH IMPEDANCE METER).
8
COMMON MODE AMPLIFIER AND SECOND-STAGE OF NORMAL MODE AMPLIFIER OPERATING PROPERLY.
MONITOR THE OUTPUT VOLTAGE (P2-5) WITH RESPECT TO OUTPUT COMMON. (P2-1).
OUTPUT VOLTAGE IS LOCKED UP NEGATIVE
OUTPUT VOLTAGE IS ZERO VOLTS ±250MV
OUTPUT VOLTAGE IS LOCKED UP POSITIVE
9
TROUBLESHOOTING THE FEEDBACK NETWORK-TROUBLESHOOTING GUIDE
10
AMPLIFIER IS OPERATIVE
PROCEED TO PARA.2.4 OF SECTION 2-INITIAL CHECKOUT PROCEDURE.
11
TROUBLESHOOT THE FEEDBACK NETWORK-TROUBLESHOOTING GUIDE V

TROUBLESHOOTING GUIDE V
SHEET 1 OF 1
MODEL 2850-COMMON MODE AMPLIFIER (CMA)

OPTION	SCHEMATIC	ASSEMBLY
V1	430440	402310, 402312
V2	430441	402331, 402312
V3	430630	402392, 402312

1. REMOVE THE AC POWER FROM THE AMPLIFIER. FOR V2 OPTION-PLACE THE MULTIPLIER SWITCH TO THE X1 POSITION.

2. MEASURE THE RESISTANCE BETWEEN THE EMITTERS OF TRANSISTOR Q2



3. THE RESISTANCE VALUE FOR EACH GAIN POSITION SHOULD BE:

GAIN	RESISTANCE
20	13.50k ±1%
50	5.38k ±1%
100	2.73k ±1%
200	1.37k ±1%
500	.539k ±1%
1000	.275k ±1%

SOME RESISTANCE VALUES BUT NOT ALL RESISTANCE VALUES ARE OUT OF TOLERANCE

4. CHECK THE GAIN RESISTOR

GAIN	RESISTOR
50	R15
100	R16
200	R17
500	R18
1000	R19

ALL RESISTANCE MEASUREMENTS ARE OUT OF TOLERANCE.

5. CHECK THE RESISTORS IN THE FEEDBACK NETWORK:

R20, R24, R21, R23, R26

AND POTENTIOMER R25.

CHECK RESISTORS R40, R41, R42 R43, R44, AND R46.

CHECK R45 AND R47; THE VALUES OF THESE TWO RESISTORS ARE STAMPED ON THE RESISTOR

RESISTANCE VALUES ARE WITHIN TOLERANCE

6. APPLY THE AC POWER TO THE AMPLIFIER.

PLACE THE GAIN SWITCH TO A HIGH GAIN POSITION(100)

CONNECT THE P-INPUT(P1-8) N-INPUT(P1-4)AND GUARD(P1-7) TO OUTPUT COMMON(P2-1)

7. MONITOR THE OUTPUT(P2-5) WITH RESPECT TO OUTPUT COMMON(P2-1).

OUTPUT IS LOCKED UP POSITIVE OR NEGATIVE

OUTPUT IS ZERO ±250MV

8. MAKE CERTAIN NONE OF THE TROUBLESHOOTING STEPS WERE OVERLOOKED

RETURN AMPLIFIER TO DANA LABORATORIES ALONG WITH REPAIR/RETURN FORM.

9. PROCEED TO PARA.2.4 OF SECTION 2 INITIAL CHECKOUT PROCEDURE

TROUBLESHOOTING GUIDE VI
SHEET 1 OF 1
MODEL 2850-FEEDBACK NETWORK

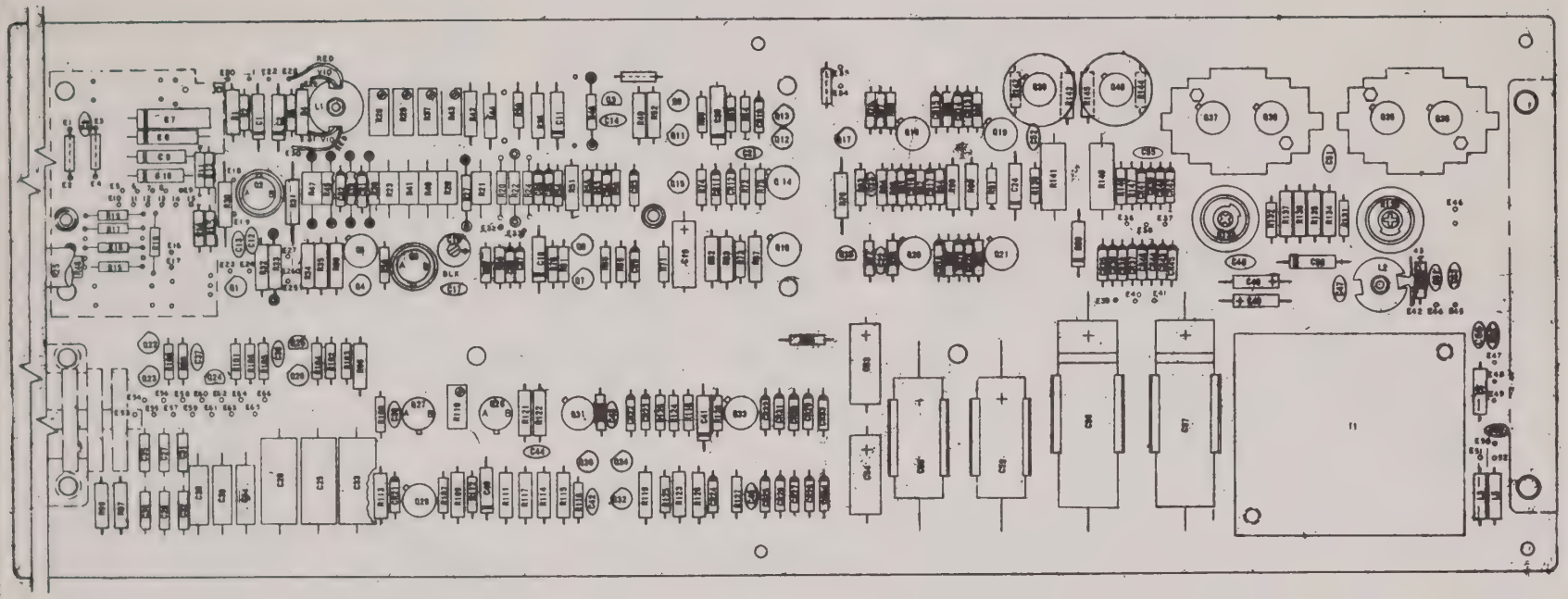
OPTION	SCHEMATIC	ASSEMBLY
V1	430440	402310, 402312
V2	430441	402331, 402312
V3	430630	402392, 402312

SECTION 7

DRAWINGS AND PARTS LISTS

7.1 DRAWINGS

PC Board Assembly 2850-V1	402310
PC Board Assembly 2850-V2	402311
PC Board Assembly 2850-V3	402392
Schematic Amplifier 2850-V1	430440
Schematic Amplifier 2850-V2	430441
Schematic Amplifier 2850-V3	430630
Outline Dimension Amplifier Model 2850	452401
Outline Dimension Enclosure Model 2808-1	452402
Outline Dimension Enclosure Model 2808-2	452403
Wiring Diagram 2808-1	430590
Wiring Diagram 2808-2	430591
Enclosure Assembly 2802-2	402948



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	FIND NO.
		LIST OF MATERIAL OR PARTS LIST			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON: DECIMALS ± ANGLES 0° 30' FORMED ANGLES ±3°

MATERIAL

FINISH

NEXT ASSY	USED ON	NA	FA
	2B50 V-1		
APPLICATION		QTY REQD	

CONTRACT NO.

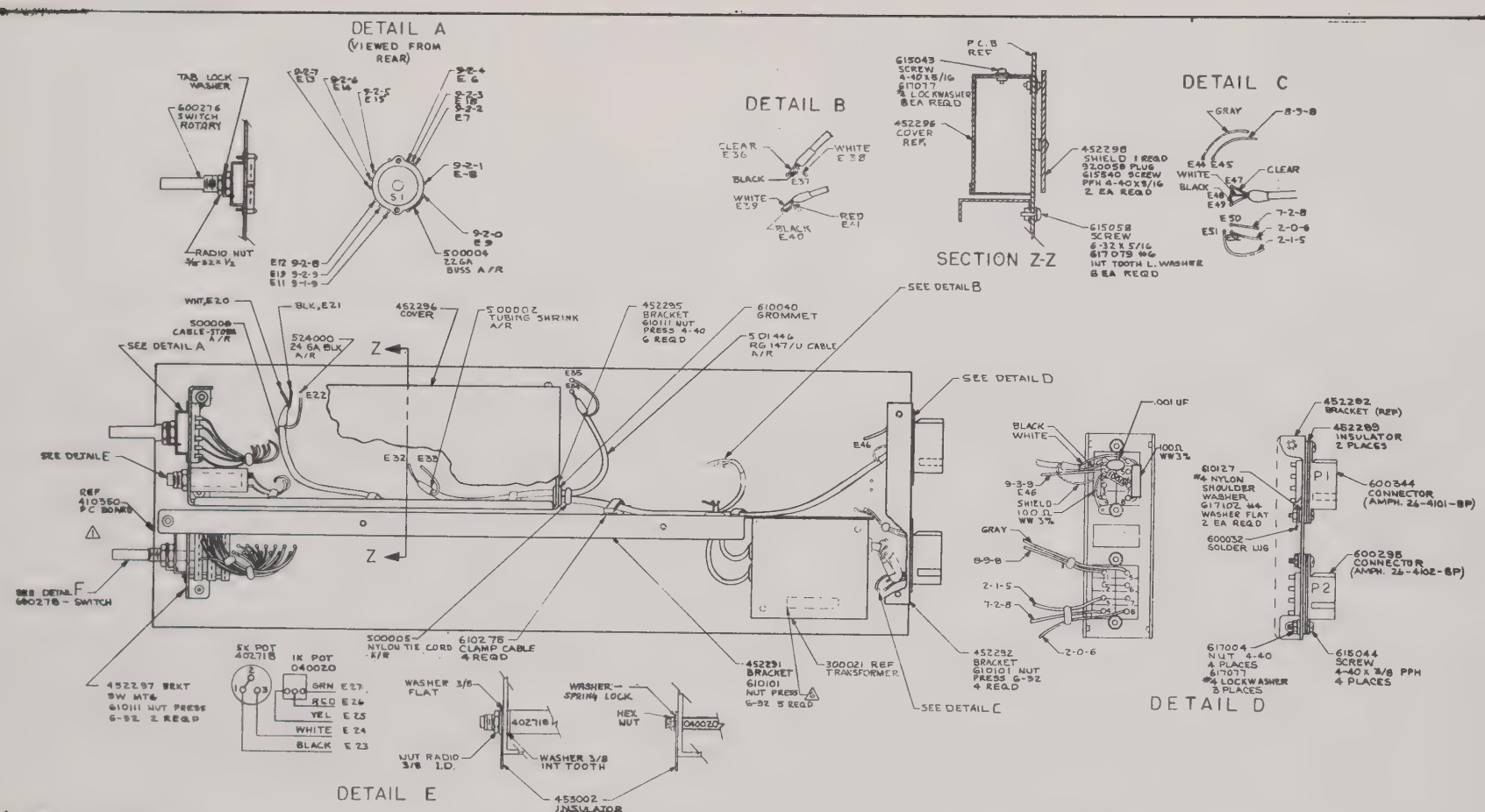
DRAWN	Jim Cabral	6/4/82
CHECK	L. Malone	6/11/82
ENGR APPR		
PROJ ENGR	Reniger	6/14/82

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BOARD ASSY—
MODEL 2B50 ORT VI

SIZE	CAGE IDENT NO.	DWG NO.	REV
D	21793	402310	

DATE 7/1/82 SHEET 1



⚠ RUBBER STAMP TOP ASSY PART NO. & LATEST REVISION APPROX WHERE SHOWN. PARSONS

3. FACTORY SELECT VALUES (FSV) TO BE DETERMINED BY DANA NO. [illegible]

4. SCHEMATIC REF [illegible]

⚠ FSV (FSV 1) AS INSTALLED DURING CHECK OUT

⚠ ASSEMBLY PROCEDURES AND PROCESSES TO CONFORM WITH DANA WORKMANSHIP STANDARDS

⚠ P C BOARD PROVED FROM COMPONENT SIDE

NOTES: UNLESS OTHERWISE SPECIFIED

[illegible]	2850 VI	1	1	
NEXT DWG	USED ON	NOT ASSY	FINAL ASSY	
APPLICATION		QTY REQD		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .030, XX .020, XXX .010
ANGLES: 0° 30' FORMED 1°0'
HOLE DIAMETERS: +.004 −.001
MATERIAL
FINISH

DRAWN	[illegible]	[illegible]
CHECK	[illegible]	[illegible]
DESIGN	[illegible]	
MECH ENGR		
PROJ ENGR		

[illegible]

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASSY — MODEL 2850 OPT VI

SIZE	CODE IDENT NO	DWG NO.	REV
D	21793	402310	[illegible]

SCALE 1/1 SHEET 3 OF 5

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C1	121002	.0022UF/100V	3
C2	121002	.0022UF/100V	REF
C3	101174	.001UF DISC	9
C4		NOT USED	
C5		NOT USED	
C6		NOT USED	
C7	121003	.047UF/100V	1
C8	121001	.033UF 100V	2
C9	121000	.015UF/100V	3
C10	121000	.01UF/100V	3
C11	121000	.01UF/100V	REF
C12	101145	100 PF DISC	4
C13	101145	100 PF DISC	REF
C14	101641	470 PF DISC	2
C15	130004	2-8 PF VARIABLE	1
C16		NOT USED	
C17	100000	5 PF DISC	1
C18	121000	.01UF/100V	REF
C19	111202	10UF/25V	1
C20	121001	.033UF/100V	REF
C21	101641	470 PF DISC	REF
C22	101174	.001UF DISC	REF
C23	101000	330 PF DISC	1
C24	121002	.0022UF/100V	REF
C25	120125	1.5UF/100V	3
C26	120130	.15UF/100V	3
C27	120131	.015UF/100V	3
C28	120132	.0012UF/100V	3
C29	120129	1.5UF/10V	REF
C30	120130	.15UF/100V	REF
C31	120131	.015UF/100V	REF
C32	120132	.0013/100V	REF
C33	120128	1.0UF/100V	REF
C34	120126	.10UF/100V	REF
C35	120131	.015UF/100V	REF
C36	120132	.0013UF/100V	REF
C37	100013	15 PF DISC	1
C38	101178	220 PF DISC	2
C39	101642	100 PF 5%	1
C40	121000	.01UF/100V	REF
C41	121473	.0015UF/100V	1
C42	101145	100 PF DISC	REF
C43	101148	180 PF DISC	REF
C44	101173	220 PF DISC	REF
C45	101174	.001UF DISC	REF
C46	111005	1UF/20V	2
C47	101182	.47 PF DISC	4
C48	101182	.47 PF DISC	REF
C49	111005	1UF/20V	REF
C50	121400	.022UF/100V	1
C51	101174	.001UF DISC	REF
C52	101182	.47 PF DISC	REF
C53	110000	50UF/25V	1
C54	110000	50UF/25V	REF
C55	101182	.47 PF DISC	REF
C56	110002	500UF/50V	2
C57	110002	500UF/50V	REF
C58	110001	100UF/50V	3
C59	110001	100UF/50V	REF
C60	121000	.01UF/100V	REF
C61	101174	.001UF DISC	REF
C62	101174	.001UF DISC	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C63	100017	.01UF DISC	1
C64	101174	.001UF DISC	REF
C65	101174	.001UF DISC	REF
C66	101174	.001UF DISC	REF
CR1	211003	018	17
CR2	211003	018	REF
CR3	221177	1/4 W 2.4 AZ5	4
CR4	221177	1/4 W 2.4 AZ5	REF
CR5	211003	018	REF
CR6	211003	018	REF
CR7	211003	018	REF
CR8	211003	018	REF
CR9	211003	018	REF
CR10	210004	SD4	21
CR11	210004	SD4	REF
CR12	210004	SD4	REF
CR13	211003	018	REF
CR14	211003	018	REF
CR15	211003	018	REF
CR16	211003	018	REF
CR17	211003	018	REF
CR18	211003	018	REF
CR19	211003	018	REF
CR20	211003	018	REF
CR21	221177	1/4 W 2.4 AZ5	REF
CR22	211003	018	REF
CR23	211003	018	REF
CR24	221177	1/4 W 2.4 AZ5	REF
CR25	210004	SD4	REF
CR26	210004	SD4	REF
CR27	210004	SD4	REF
CR28	210004	SD4	REF
CR29	210004	SD4	REF
CR30	210004	SD4	REF
CR31	210004	SD4	REF
CR32	210004	SD4	REF
CR33	220018	1N6648	2
CR34	220018	1N6648	REF
CR35	210004	SD4	REF
CR36	220011	1N6649	2
CR37	220011	1N6649	REF
CR38	210004	SD4	REF
CR39	210004	SD4	REF
CR40	210004	SD4	REF
CR41	210004	SD4	REF
CR42	210004	SD4	REF
CR43	210004	SD4	REF
CR44	210004	SD4	REF
CR45	210004	SD4	REF
CR46	210004	SD4	REF
L1	406316	RF CHOKE	1
L2	406324	90 UH	1
L3	310033	100 UH	3
L4	310033	100 UH	REF
L5	310033	100 UH	REF
Q1	20043	2N3565	18
Q3	402716	FSV ASSY	REF
Q3	200022	012	4
Q4	200043	2N3565	REF
Q5	291265	2ND STAGE DUAL	1

REF DES OR ITEM	P/N	DESCRIPTION	QTY
Q6	200078	814 GRADED	1
Q7	200043	2N3565	REF
Q8	200043	2N3565	REF
Q9	200043	2N3565	REF
Q10	200036	614	1
Q11	200043	2N3565	REF
Q12	200043	2N3565	REF
Q13	200043	2N3565	REF
Q14	200011	009	REF
Q15	200043	2N3565	REF
Q16	200022	012	REF
Q17	200043	2N3565	REF
Q18	200035	014	REF
Q19	200011	009	REF
Q20	200022	012	REF
Q21	200043	2N3565	REF
Q22	200040	Q18 DUAL	2
Q23	200040	Q18 DUAL	REF
Q24	200035	014	REF
Q25	200011	009	REF
Q26	200043	2N3565	REF
Q27	200040	Q18 DUAL	REF
Q28	200035	014	REF
Q29	200043	2N3565	REF
Q30	200011	009	REF
Q31	200011	009	REF
Q32	200043	2N3565	REF
Q33	200011	009	REF
Q34	200043	2N3565	REF
Q35	200034	014	REF
Q36	200035	014	REF
Q37	200011	009	REF
Q38	200035	014	REF
Q40	200011	009	REF
R1	020100	100 OHMS 3% 1W	4
R2	000302	3.9 k	8
R3		NOT USED	
R4	020100	100 OHMS 3% 1W	REF
R5	000302	3.9 k	REF
R6		NOT USED	
R7		NOT USED	
R8		NOT USED	
R9		NOT USED	
R10		NOT USED	
R11	000621	620 OHMS	1
R12	000152	1.5 k	2
R13	000242	2.4 k	1
R14	000472	4.7 k	2
R15	020424	9.178 k WW .05%	1
R16	020423	3 442 k WW .05%	1
R17	020422	1.530 k 22 .05%	1
R18	020421	579.7 k WW .05%	1
R19	020420	261 OHMS WW .05%	1
R20	402718	FSV ASSY	REF
R21	020008	640 OHMS WW .1%	1
R22	402718	FSV ASSY	REF
R23	020078	100 k WW .1%	2
R24	402718	FSV ASSY	REF
R25	402718	FSV ASSY	REF
R26	020078	100 k WW .1%	REF
R27	402718	FSV ASSY	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R28	040092	20 k POT	2
R29	040092	20 k POT	REF
R30	011178	4.99 M RN60X	2
R31	011178	4.99 M RN60X	REF
R32	010130	6.19 k RN60D	1
R33	402716	FSV ASSY	REF
R34	010058	20 k RN60D	REF
R35	010058	20. k RN60D	8
R36	010110	10 k RN65C	1
R37	040093	500 OHMS POT	1
R38	402718	FSV ASSY	REF
R39	402718	FSV ASSY	REF
R40	020078	50 k WW .1%	2
R41	020078	50 k WW .1%	REF
R42	020425	10.455 k WW .1%	2
R43	040108	50 OHMS POT	1
R44	020425	10.455 k WW .1%	REF
R45	402718	FSV ASSY	REF
R46	040020	1 k POT	1
R47	402716	FSV ASSY	REF
R48	402718	FSV ASSY	REF
R49	010020	4.99 k RN60D	5
R50	020104	3.75 k WW .1%	1
R51	010029	4.99 k RN60D	REF
R52	010020	4.99 k RN60D	REF
R53	000512	5.1 k	1
R54	000152	15 k	3
R55	000752	7.5 k	2
R56	000123	12 k	2
R57	000393	39 k	4
R58	000393	39 k	REF
R59	000104	100 k	2
R60	010018	30.1 k RN60D	1
R61	000153	15 k	REF
R62	011334	2.81 k RN60D	1
R63	010008	1.4 k RN60D	1
R64	000103	10 k	6
R65	000103	10 k	REF
R66	000221	220 OHMS	2
R67	010027	499 OHMS RN60D	1
R69	000123	12 k	REF
R69	000103	10 k	REF
R70	000204	200 k	1
R71	000221	220 OHMS	REF
R72	000823	82 k	1
R73	000222	2.2 k	1
R74	000153	15 k	REF
R75	000152	1.5 k	REF
R78	020118	680 OHMS WW 1%	1
R77	000822	8.2 k	1
R78	000223	22 k	1
R79	000472	4.7 k	REF
R80	000393	39 k	REF
R81	000201	200 OHMS	4
R82	000201	200 OHMS	REF
R83	000103	10 k	REF
R84	000393	39 k	REF
R85	000122	1.2 k	2
R88	000501	51 OHMS	2
R87	000201	200 OHMS	REF
R88	000201	200 OHMS	REF
R89	001158	330 OHMS 1/2W 5%	2
R90	001158	330 OHMS 1/2W 5%	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
R91	000273	27 k	1
R92	000122	1.2 k	REF
R93	000510	51 OHMS	REF
R94	000124	120 k	1
R95	010008	9.53 k RN60D	3
R96	010020	4.99 k RN60D	REF
R97	010324	10.7 k RN60D	1
R98	010211	4.42 k RN60D	1
R99	000822	8.2 k	1
R100	000104	100 k	REF
R101	000302	3 k	1
R102	000301	300 OHMS	2
R103	000162	1.8 k	1
R104	000183	18 k	1
R105	000151	150 OHMS	2
R106	000202	2 k	2
R107	000752	7.5 k	REF
R108	000103	10 k	REF
R109	010082	8.31 k RN60D	2
R110	040109	5 k POT	1
R111	010082	8.31 k RN60D	REF
R112	000202	2 k	REF
R113	010088	6.45 k RN60D	1
R114	011332	1 k RN60D	2
R115	010084	54.9 k RN60D	1
R116	000102	1 k	3
R117	011332	1 k RN60D	REF
R118	000102	1 k	REF
R119	010113	15 k RN60D	1
R120	000103	10 k	REF
R121	010020	4.99 k RN60D	REF
R122	010086	8.53 k RN60D	REF
R123	010087	11.5 k RN60D	1
R124	000393	3.9 k	REF
R125	000393	3.9 k	REF
R126	010137	900 OHMS 3W5%	1
R127	000102	1 k	REF
R128	000471	470 OHMS	1
R129	000301	300 OHMS	REF
R130	040022	500 OHMS POT	2
R131	000681	680 OHMS	2
R132	000681	680 OHMS	REF
R133	040022	500 OHMS POT	REF
R134	001898	20 OHMS 1/2 W 5%	4
R135	001898	20 OHMS 1/2W 5%	REF
R136	001898	20 OHMS 1/2W 5%	REF
R137	001898	20 OHMS 1/2W 5%	REF
R138	000100	10 OHMS	3
R139	000362	3.6 k	REF
R140	000362	3.6 k	REF
R141	000302	3.0 k	2
R142	000100	10 OHMS	REF
R143	001682	1.5 k 1/2W 5%	2
R144	000100	10 OHMS	REF
R145	001682	1.5 k 1/2W 5%	REF
R146	030003	30 OHMS 2W 5%	REF
R147	000151	150 OHMS	REF
R148	020109	100 OHMS WW 3%	REF
R149	020108	100 OHMS WW 3%	REF
R150	000101	100 OHMS	1
T1	300021	TRANSFORMER	1

P/N	DESCRIPTION	QTY
402718	FSV ASSY	1
410350	PCB AMPL 100W DP	1
	W VARIBAND	
430440	SCHEMATIC AMPL V1	REF
452289	INSULATOR	2
452291	BRACKET-SUPPORT	1
452292	BRACKET-CONN MTG	1
452295	BRACKET-ELEC SHLD	1
452296	COVER-ELEC SHLD	1
452297	BRKT-SW MTG	1
452298	SHIELD-ELECSTAT	1
452343	CASE-MODIFIED	2
	920258	
453002	INSL-POT MTG	1
452725	CLIP-COMP	2
452726	CLIP-COMP	2
452723	STDOFF-COMP	22
	SUPPORT	
500002	TUBING-SHRINK	A/R
	.153 I D	
500004	WIRE BUSS	A/R
500005	NYLON TIE CORD	A/R
500008	CABLE-STORM	A/R
501448	CABLE-RG 174/U	A/R
542000	WIRE 0 COLOR	A/R
524206	WIRE 2-9-8	A/R
	COLOR	
524215	WIRE 2-1-5	A/R
524728	WIRE 7-2-8	A/R
	COLOR	
524888	WIRE 8 COLOR	A/R
524898	WIRE 8-9-8	A/R
	COLOR	
524910	WIRE 9-1-9	A/R
	COLOR	
524811	WIRE 8-1-1	A/R
	COLOR	
524912	WIRE 9-1-2	A/R
	COLOR	
524913	WIRE 9-1-3	A/R
	COLOR	
524914	WIRE 9-1-4	A/R
	COLOR	
524815	WIRE 8-1-5	A/R
	COLOR	
524816	WIRE 9-1-6 COLOR	A/R
524817	WIRE 9-1-7 COLOR	A/R
524818	WIRE 9-1-8 COLOR	A/R
524819	WIRE 9-1-9 COLOR	A/R
524820	WIRE-9-2-0 COLOR	A/R
524821	WIRE-9-2-1 COLOR	A/R
524822	WIRE-9-2-2 COLOR	A/R
524823	WIRE-9-2-3 COLOR	A/R
524824	WIRE-9-2-4 COLOR	A/R
524825	WIRE-9-2-5 COLOR	A/R
524826	WIRE-9-2-6 COLOR	A/R
524827	WIRE-9-3-7 COLOR	A/R
524828	WIRE-9-2-8 COLOR	A/R
524829	WIRE-9-2-9 COLOR	A/R
524839	WIRE-9-3-9 COLOR	A/R
524899	WIRE-9-8-9 COLOR	A/R
800018	HEAT SINK	2
800032	LUG-SOLDER	1

P/N	DESCRIPTION	QTY
600068	HEAT DISS	2
600245	JUMPER-INSUL	4
600278	SWITCH-ROT 2 POL 6 POS	1
600279	SWITCH-ROT 3 POL 10 POS	1
600295	CONN-PLUG	1
600287	CONN-PC JACK	18
600344	CONN-8 PINS	1
810019	RIVET-1/8 SEMI-TUB X 5/32 LG	8
810040	GROMMET-RUB	1
810101	NUT-PRESS 8-32	9
810111	NUT-PRESS 4-40	8
610127	WASH-SHOULD NYL	2
610198	#4 NYLON WASHER	4
610252	STDOFF-SW 4-40 X 1/8 LG	2
810275	CLAMP-CABLE PL	4
815015	SCREW PPH 2-56 X 5/16	4
815043	SCREW PPH 4-40 X 5/16	8
815044	SCREW PPH 4-40 X 3/8	4
815047	SCREW PPH 4-40 X 5/8	2
815058	SCREW PPH 8-32 X 5/16	8
815540	SCREW PFH 4-40 X 3/16	2
817004	HEX NUT 4-40 STD	4
817014	HEX NUT 2-56 RAD	4
817016	HEX NUT 4-40 RAD	2
817075	WASHER INT LOCK #2	4
817077	WASHER INT LOCK #4	13
817078	WASHER INT LOCK #8	8
817102	WASHER-FLAT, LIGHT SERIES 4	4
820006	TRANS PAD LARGE	12
820010	SOLDER-BAR	A/R
820028	SOLDER-WIRE	A/R
820058	PLUG	2
920082	TRANS PAD	4
920271	CAP-ENCAPSULATING BLK	2

NEXT DWG	USED ON	NEXT ASSY	FINAL ASSY
402307	2850-V1	REF	REF
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: X .030, XX .020, XXX .010
ANGLES: 0° 30' FORMED ± 1°
HOLE DIAMETERS: ± .004, .001
MATERIAL
FINISH

DRAWN	J. EDWARDS	7/18/68
CHECK	R PRCHAL	7/18/68
DESIGN	V. SOLBERG	8/6/68
MECH ENGR		
PROJ ENGR	RENIERI	8/29/68

DRW # 687
Rev 11-3-67

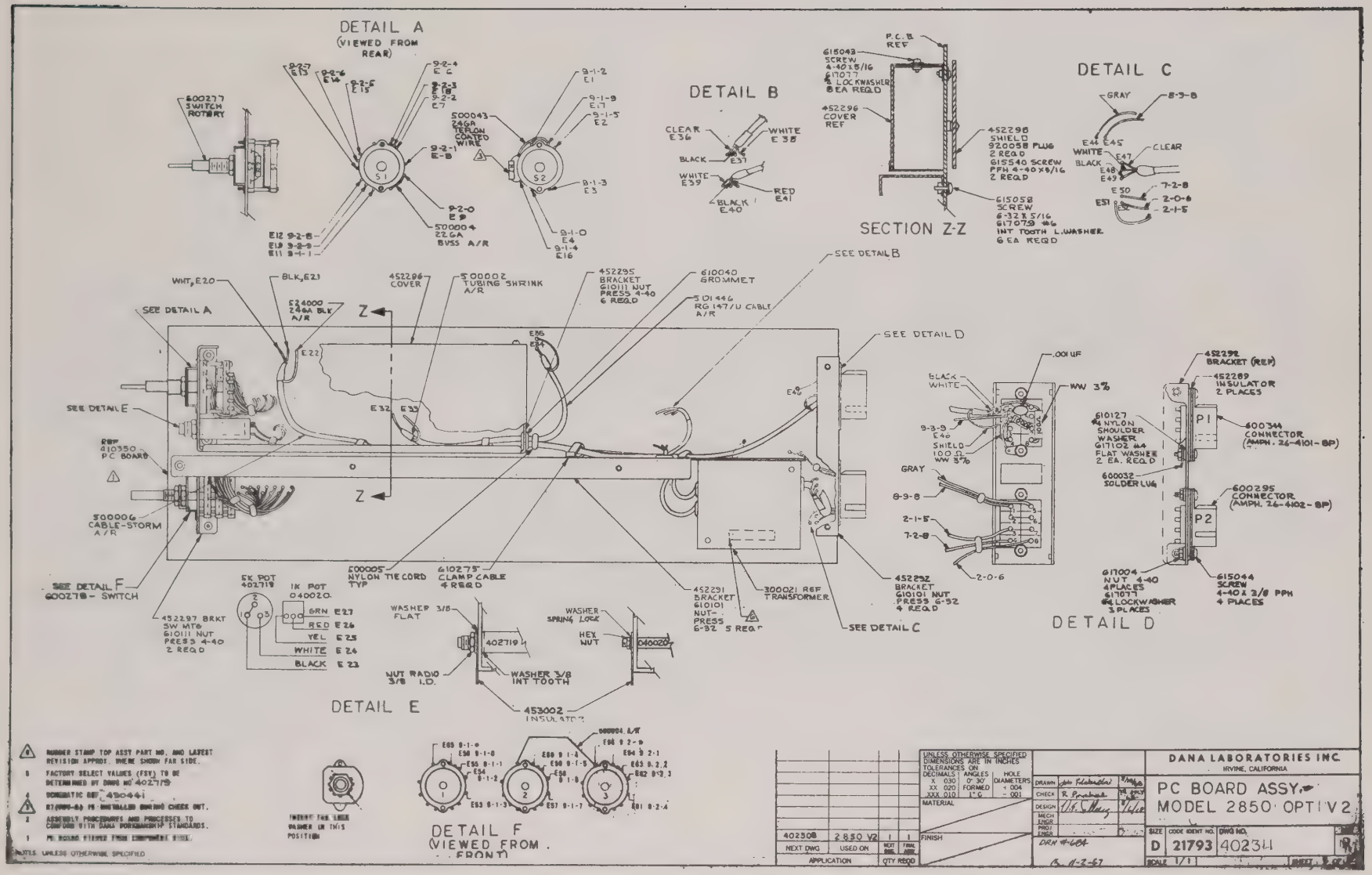
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P C BOARD ASSY -
MODEL 2850, OPT V1

SIZE	CODE IDENT NO.	DWG NO	REV
D	21793	402310	N

SCALE NONE | SHEET 5 OF 5

NOTES UNLESS OTHERWISE SPECIFIED



A RUBBER STAMP TOP ASSY PART NO. AND LATEST REVISION APPROD. WHERE SHOWN FAR SIDE.

B FACTORY SELECT VALUES (FSV) TO BE DETERMINED BY DWG NO 402719

SCHEMATIC 480441

R7(600-6) PR INSTALLED (ONLY) CHECK OUT.

2 ASSEMBLY PROCEDURES AND PROCESSES TO COMPLY WITH DANA WORKMANSHIP STANDARDS.

1 PC BOARD FIBERGLASS [illegible]

NOTES: UNLESS OTHERWISE SPECIFIED

402308	2850 V2	1	1
NEXT DWG	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: X .030, XX .020, XXX .010
ANGLES: 0° 30' FORMED ± .005
HOLE DIAMETERS: ± .004, ± .001
MATERIAL
FINISH

DRAWN	John Hildebrandt	9/24/65
CHECK	R. Prahaska	9/24/65
DESIGN	W. S. Mauz	9/24/65
MECH ENGR		
PROJ ENGR		

DRN # L-64

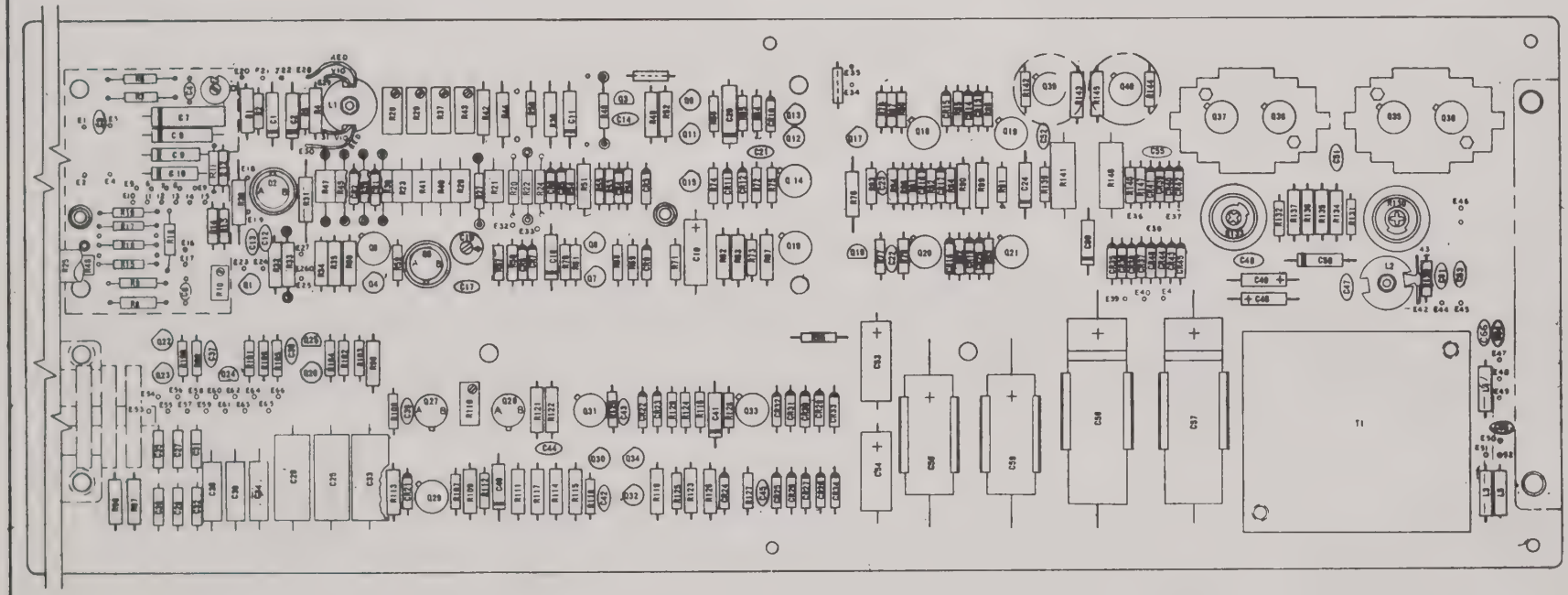
B 11-2-67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

PC BOARD ASSY, MODEL 2850 OPT V2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402341	R

SCALE 1/1 SHEET 1 OF 1



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
402308	2850 V2	1			
NEXT ASSY	USED ON	NA	FA		
APPLICATION		QTY REQD			

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .020, .XX .010, .XXX .005
ANGLES 0° 30'
FORMED ANGLES 1.0
MATERIAL
FINISH

CONTRACT NO.

DRAWN	Jim Garcau	5/9/67
CHECK	L. Malouf	5/9/67
COG. ENGR		
PROJ ENGR	Reuiert	6/1/67

DRN # 689
CA 11-21-67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C. BOARD ASSY—
MODEL 2850 OPT. V2

SIZE	CAGE IDENT NO.	DWG NO.	REV
D	21793	402311	

SCALE 2/1 WT

NOTE: UNLESS OTHERWISE SPECIFIED

REF DES OR ITEM	P/N	DESCRIPTION	QTY
C1	131082	.002.2MF/100V	3
C2	121082	.0022MF/100V	REF
C3	101174	.001MF DISC	8
C4	100906	15pF DISC	2
C5	130994	2.0pF DISC	2
C6	101641	470pF DISC	3
C7	121083	.047MF/100V	1
C8	121081	.033MF/100V	2
C9	121080	.01MF/100V	5
C10	121086	.01MF/100V	5
C11	121086	.01MF/100V	REF
C12	101145	100 pF DISC	4
C13	101145	100 pF DISC	REF
C14	101641	470 pF DISC	REF
C15	130004	2-8 pF VARIABLE	REF
C16		NOT USED	REF
C17	100088	5 pF DISC	1
C18	121080	.01MF/100V	REF
C19	111262	100F/25V	1
C20	121081	.033MF/100V	REF
C21	101641	470 pF DISC	REF
C22	101174	.001MF DISC	REF
C23	101066	330 pF DISC	1
C24	121082	.0022MF/100V	REF
C25	120128	1.5JF/100V	3
C26	120130	.15MF/100V	3
C27	120131	.015MF/100V	3
C28	120132	.0013MF/100V	3
C29	120129	1.5MF/100V	REF
C30	120130	.15MF/100V	REF
C31	120131	.015MF/100V	REF
C32	120133	.0013/100V	REF
C33	120129	1.5MF/100V	REF
C34	120130	.15MF/100V	REF
C35	120131	.015MF/100V	REF
C36	120132	.0013MF/100V	REF
C37	100013	15pF DISC	1
C38	101175	220 pF DISC	2
C39	101642	150 pF DISC	1
C40	121080	.01MF/100V	REF
C41	121473	.001MF/100V	1
C42	101146	180 pF DISC	REF
C43	101146	180 pF DISC	REF
C44	101176	220 pF DISC	REF
C45	101174	.001MF DISC	REF
C46	111095	10F/35V	2
C47	101102	47 pF DISC	4
C48	101102	47 pF DISC	REF
C49	111095	10F/35V	REF
C50	121468	.022MF/100V	1
C51	101174	.001MF DISC	REF
C52	101102	47 pF DISC	REF
C53	110868	50MF/25V	2
C54	110868	50MF/25V	REF
C55	101102	47 pF DISC	REF
C56	110882	500MF/10V	2
C57	110882	500MF/50V	REF
C58	110881	100MF/50V	2
C59	110881	100MF/50V	REF
C60	121080	.01MF/100V	REF
C61	101174	.001MF DISC	REF
C62	101174	.001MF DISC	REF
C63	100017	.01MF DISC	1
C64	101174	.001MF DISC	REF
C65	101174	.001MF DISC	REF
C66	101174	.001MF DISC	REF

REF DES OR ITEM	P/N	DESCRIPTION	QTY
CR1	211083	010	17
CR2	211083	010	REF
CR3	221177	1/4 W 2.4 AZ5	4
CR4	221177	1/4 W 2/4 AZ5	REF
CR5	211083	010	REF
CR6	211083	010	REF
CR7	211083	010	REF
CR8	211083	010	REF
CR9	211083	010	REF
CR10	210084	SD4	21
CR11	210084	SD4	REF
CR12	210084	SD4	REF
CR13	211083	010	REF
CR14	211083	010	REF
CR15	211083	010	REF
CR16	211083	010	REF
CR17	211083	010	REF
CR18	211083	010	REF
CR19	211083	010	REF
CR20	211083	010	REF
CR21	221177	1/4W 2 4AZ5	REF
CR22	211083	010	REF
CR23	211083	010	REF
CR24	221177	1/4W 2 4AZ5	REF
CR25	210084	SD4	REF
CR26	210084	SD4	REF
CR27	210084	SD4	REF
CR28	210084	SD4	REF
CR29	210084	SD4	REF
CR30	210084	SD4	REF
CR31	210084	SD4	REF
CR32	210084	SD4	REF
CR33	220016	IN5648	2
CR34	220016	IN5648	REF
CR35	210084	SD4	REF
CR36	220011	IN5508	2
CR37	220011	IN5508	REF
CR38	210084	SD4	REF
CR39	210084	SD4	REF
CR40	210084	SD4	REF
CR48	210084	SD4	REF
L1	400315	RF CHOKE	1
L2	400324	90 UH	1
L3	310033	100 UH	3
L4	310033	100 UH	REF
L5	310033	100 UH	REF
Q1	200043	2N3565	18
Q2	402719	FSV ASSY	REF
Q3	200022	012	4
Q4	200043	2N3565	REF
Q5	201285	2NB STAGE DUAL	1
Q6	200078	014 GRADED	1
Q7	200043	2N3565	REF
Q8	200843	2N3565	REF
Q9	200843	2N3565	REF
Q10	200828	014	7
Q11	200843	2N3565	REF
Q12	200843	2N3565	REF
Q13	200843	2N3565	REF
Q14	200811	088	8
Q15	200843	2N3565	REF
Q16	200822	012	REF
Q17	200843	2N3565	REF
Q18	200835	014	REF
Q19	200811	088	REF
Q20	200811	088	REF
Q21	200835	014	REF
Q22	200843	2N3565	REF
Q23	200843	2N3565	REF
Q24	200822	012	REF
Q25	200822	012	REF
Q26	200843	2N3565	REF
Q27	200840	Q18 DUAL	2
Q28	200848	Q18 DUAL	REF
Q29	200835	014	REF
Q30	200843	2N3565	REF
Q31	200811	088	REF
Q32	200843	2N3565	REF
Q33	200811	088	REF
Q34	200843	2N3565	REF
Q35	200835	014	REF
Q36	200835	014	REF
Q37	200811	088	REF
Q38	200811	088	REF
Q39	200835	014	REF
Q40	200811	088	REF
R1	020106	100 OHMS 3% WW	4
R2	000302	3.0 k	8
R3	010111	1MS MFR96SC	2
R4	020106	100 OHMS 3% WW	REF
R5	000302	3.0 k	REF
R6	010111	1MS MFR96SC	REF
R7	402719	FSV ASSY	REF
R8	020097	10K WW 1%	2
R9	020097	10K WW 1%	REF
R10	040093	500 OHM POT	2
R11	000921	620 OHMS	1
R12	000152	1.5 k	2
R13	000242	2.4 k	1
R14	000472	4.7 k	2
R15	020424	9.178 k WW .05%	1
R16	020423	3.442 k WW .05%	1
R17	020422	1.530 k WW .05%	1
R18	020421	573.7 WW .05%	1
R19	020429	281 OHMS WW .05%	1
R20	402719	FSV ASSY	REF
R21	020086	848 OHMS WW .1%	1
R22	402719	FSV ASSY	REF
R23	020079	100 k WW 1%	2
R24	402719	FSV ASSY	REF
R25	402719	FSV ASSY	REF
R26	020079	100 k WW .1%	REF
R27	402719	FSV ASSY	REF
R28	040082	20 k POT	2
R29	040082	20 k POT	REF
R30	011178	4.96 W .002%	2
R31	011178	4.96 W .002%	REF
R32	010139	6.19 k .005%	1
R33	402719	FSV ASSY	REF
R34	010858	20 k .005%	2
R35	010858	20 k .005%	REF
R36	010118	10 k .005%	1
R37	040093	500 OHMS POT	REF
R38	402719	FSV ASSY	REF
R39	402719	FSV ASSY	REF
R40	020078	50 k WW .1%	2
R41	020076	50 k WW .1%	REF
R42	020425	10.455 k WW .1%	2
R43	040108	50 OHMS POT	1
R44	020429	10.496 k WW .1%	REF
R45	402719	FSV ASSY	REF
R46	040020	1 k POT	1
R47	402719	FSV ASSY	REF
R48	402719	FSV ASSY	REF
R49	010020	4.99 k .005%	9
R50	020104	3.75 k WW 1%	1
R51	010020	4.99 k .005%	REF
R52	010020	4.99 k .005%	REF
R53	000512	9.1 k	1
R54	000153	15 k	3
R55	000752	7.5 k	2
R56	000123	12 k	2
R57	000303	30 k	4
R58	000303	30 k	REF
R59	000104	100 k	2
R60	010019	30.1 k .005%	1
R61	000153	15 k	REF
R62	011334	2.81 k .005%	1
R63	010008	1.4 k .005%	1
R64	000103	10 k	8
R65	000103	10 k	REF
R66	000221	220 OHMS .005%	2
R67	010027	499 OHMS .005%	1
R68	000123	12 k	REF
R69	000103	10 k	REF
R70	000204	200 k	1
R71	000221	220 OHMS	REF
R72	000823	82 k	1
R73	000222	2.2 k	1
R74	000153	15 k	REF
R75	000152	1.5 k	REF
R76	020119	600 OHMS WW 1%	1
R77	000822	8.2 k	1
R78	000223	22 k	1
R79	000472	4.7 k	REF
R80	000303	30 k	REF
R81	000201	200 OHMS	4
R82	000201	200 OHMS	REF
R83	000103	10 k	REF
R84	000303	30 k	REF
R85	000122	1.2 k	2
R86	000510	51 OHMS	2
R87	000201	200 OHMS	REF
R88	000201	200 OHMS	REF
R89	001159	330 OHMS 1/2W 5%	2
R90	001159	330 OHMS 1/2W 5%	REF
R91	000273	27 k	1
R92	000122	1.2 k	REF
R93	000510	51 OHMS	REF
R94	000124	120 k	1
R95	010066	9.53 k .005%	2
R96	010020	4.99 k .005%	REF
R97	010324	10.7 k .005%	1
R98	010211	4.42k .005%	1
R99	000822	8.2 k	1
R100	000104	100 k	REF
R101	000302	3 k	1
R102	000301	300 OHMS	2
R103	000152	1.5 k	1
R104	000103	10 k	1
R105	000151	150 OHMS	2
R106	000202	2 k	2
R107	000752	7.5 k	REF
R108	000103	10 k	REF
R109	010082	8.31 k .005%	2
R110	040103	5 k POT	1
R111	010062	9.31 k .005%	REF
R112	000202	2 k	REF
R113	010088	8.45 k .005%	1
R114	011332	1 k .005%	2
R115	010084	84.5 k .005%	1
R116	000102	1 k	3
R117	011332	1 k .005%	REF
R118	000102	1 k	REF
R119	010113	15 k .005%	1
R120	000103	10 k	REF
R121	010020	4.99 k .005%	REF
R122	010086	9.53 k .005%	REF
R123	010087	11.5 k .005%	1
R124	000382	3.8 k	REF
R125	000392	3.8 k	REF
R128	010137	100 OHMS .005%	1
R127	000102	1 k	REF
R128	000471	470 OHMS	1
R129	000301	300 OHMS	REF
R130	040022	500 OHMS POT	2
R131	000681	680 OHMS	2
R132	000501	680 OHMS	REF
R133	040022	500 OHMS POT	REF
R134	001889	20 OHMS 1/2W 5%	4
R135	001890	20 OHMS 1/2W 5%	REF
R136	001890	20 OHMS 1/2W 5%	REF
R137	001889	20 OHMS 1/2W 5%	REF
R138	000100	10 OHMS	3
R139	000392	3.8 k	REF
R140	000382	3.8 k	REF
R141	038003	38 OHMS 2W 5%	2
R142	000100	10 OHMS	REF
R143	001882	1.5 k 1/2W 5%	2
R144	000100	10 OHMS	REF
R145	001882	1.5 k 1/2W 5%	REF
R146	038003	38 OHMS 2W 5%	REF
R147	000151	150 OHMS	REF
R148	020106	100 OHMS WW 3%	REF
R149	020106	100 OHMS WW 3%	REF
R150	000101	100 OHMS	1
T1	300021	TRANSFORMER	1
	402719	FSV ASSY	1
	418390	PCB AMPL 100M OP V VARIDAND	1
	428348	ARTWORK AMPL 100M OP V VARI	REF
	430441	SCHEMATIC AMPL V2	REF
	452289	INSULATOR	2
	452281	BRACKET-SUPPORT	1
	452292	BRACKET-CONN MTG	1
	452285	BRKT ELEC SHLD	1
	452296	COVER ELEC SHLD	1
	452287	BRKT SP MTG	1
	452280	SHIELD-ELECSTAT	1
	452343	CASE MODIFIED 020256 NYGLASS	2
	452305	INSULATOR	1
	452725	CLIP COMP .560 DIA MTG	2
	452726	CLIP COMP .800 DIA MTG	2
	452723	STANDOFF COMP. SUPPORT	22
	500002	TUBING SHRINK .153 I.D.	A/R
	500004	WIRE BUSS 22 GA	A/R
	500005	NYLON TIE CORD	A/R
	500006	CABLE STORE	A/R
	500043	WIRE-24 GA WHT	A/R
	501448	CABLE RG 174/U	A/R
	524000	WIRE-24GA STR 0 COLOR	A/R
	524206	WIRE 24GA STR 2-0-6 COLOR	A/R
	524215	WIRE 24GA STR 2-1-5	A/R
	524728	WIRE 24GA STR 7-2-8 COLOR	A/R
	524889	WIRE 24GA STR 8-8-8 COLOR	A/R
	524998	WIRE 24GA STR 9-9-8 COLOR	A/R
	524910	WIRE 24GA STR 0-1-0 COLOR	A/R
	524911	WIRE-24 GA STR 0-1-1 COLOR	A/R
	524912	WIRE-24 GA STR 0-1-2 COLOR	A/R
	524913	WIRE-24 GA STR 0-1-3 COLOR	A/R
	524914	WIRE-24 GA STR 0-1-4 COLOR	A/R
	524915	WIRE-24 GA STR 0-1-5 COLOR	A/R
	524916	WIRE-24 GA STR 0-1-6 COLOR	A/R
	524917	WIRE-24 GA STR 0-1-7 COLOR	A/R
	524918	WIRE-24 GA STR 0-1-8 COLOR	A/R
	524919	WIRE 24GA STR 0-1-9 COLOR	A/R
	524920	WIRE-24 GA STR 0-2-0 COLOR	A/R
	524921	WIRE-24 GA STR 0-2-1 COLOR	A/R
	524922	WIRE-24 GA STR 0-2-2 COLOR	A/R
	524923	WIRE-24 GA STR 0-2-3 COLOR	A/R
	524924	WIRE-24 GA STR 0-2-4 COLOR	A/R
	524925	WIRE-24 GA STR 0-2-5 COLOR	A/R
	524926	WIRE-24 GA STR 0-2-6 COLOR	A/R
	524927	WIRE-24 GA STR 0-2-7 COLOR	A/R
	524928	WIRE-24 GA STR 0-2-8 COLOR	A/R
	524929	WIRE 24GA STR 0-2-9 COLOR	A/R
	524939	WIRE 24GA STR 0-3-9 COLOR	A/R
	524999	WIRE 24GA STR 0-9-9 COLOR	A/R
	600018	HEAT SINK IERC TEOF-082-0258	2
	600032	LUG-SOLDER	1
	600080	IERC LPS030 HEAT DISS	2
	600245	JUMPER-INSUL GETTING-2007-1	4
	600277	SWITCH HDT 2 DBL 6 POS	1
	600278	SWITCH ROTARY 3 POL. 10 POS	1
	600295	CONN-PLUG AMPHENOL 28-4102-8P	1
	600297	CONN-PC JACK CARDJOB-3304-2-99	16
	600344	CONN 8 PINS AMPH 28-4101-8P	1
	610019	RIVET-1/8 SEMI-TUB X 5/32 LG	8
	610048	GROMMET RUB 1/4 I.D X 3/8	1
	610101	NUT-PRESS 8-32 PEM S-832-1	8
	610111	NUT-PRESS, 4-40, PEM S-440-1	8
	610127	WASH-SHOULD. NYL, 4 SCREW	2
	610190	# 4 NYLON WASHER	4
	610232	STDOFF-SW 4-40 X 1/8LG 1/4D .06 MTG	2
	610275	CLAMP CABLE PL, 500016 9-4-1	4
	610316	SCREW PPH 2-56 X 5/16 STLS	4
	610643	SCREW PPH 4-40 X 5/16 STLS	8
	610644	SCREW PPH 4-40 X 3/8 STLS	4
	610647	SCREW PPH 4-40X 5/8 STLS	2
	610650	SCREW PPH 8-32 X 5/16 STLS	8
	610660	SCREW PPH 4-40 X 3/16 STLS	2
	617004	HEX NUT 4-40 STD STLS	4
	617014	HEX NUT 2-56 BRASS STLS	4
	617018	HEX NUT 4-40 BRASS STLS	2
	617075	WASHER INT LOCK 2 STLS	4
	617077	WASHER INT LOCK 4 STLS	15
	617079	WASHER INT LOCK 6 STLS	8
	617102	WASHER-FLAT, LIGHT SERIES 4 STLS	2
	620006	TRANS PAD-LARGE	12
	620016	SOLDER BAR	6/8
	620026	SOLDER WIRE .03263/37 RESIN CORE	A/R
	620050	PLUG PLASTEX 207-000047-000160	2
	620063	TRANS PAD MOSS 10037	36
	620271	CAP ENCAPSULATING NYGLASS #4 BLK	2

REVISIONS			
LTR	DESCRIPTION	DR	CHK	APPD
	SEE SHEET 1			

QTY REQD	* DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

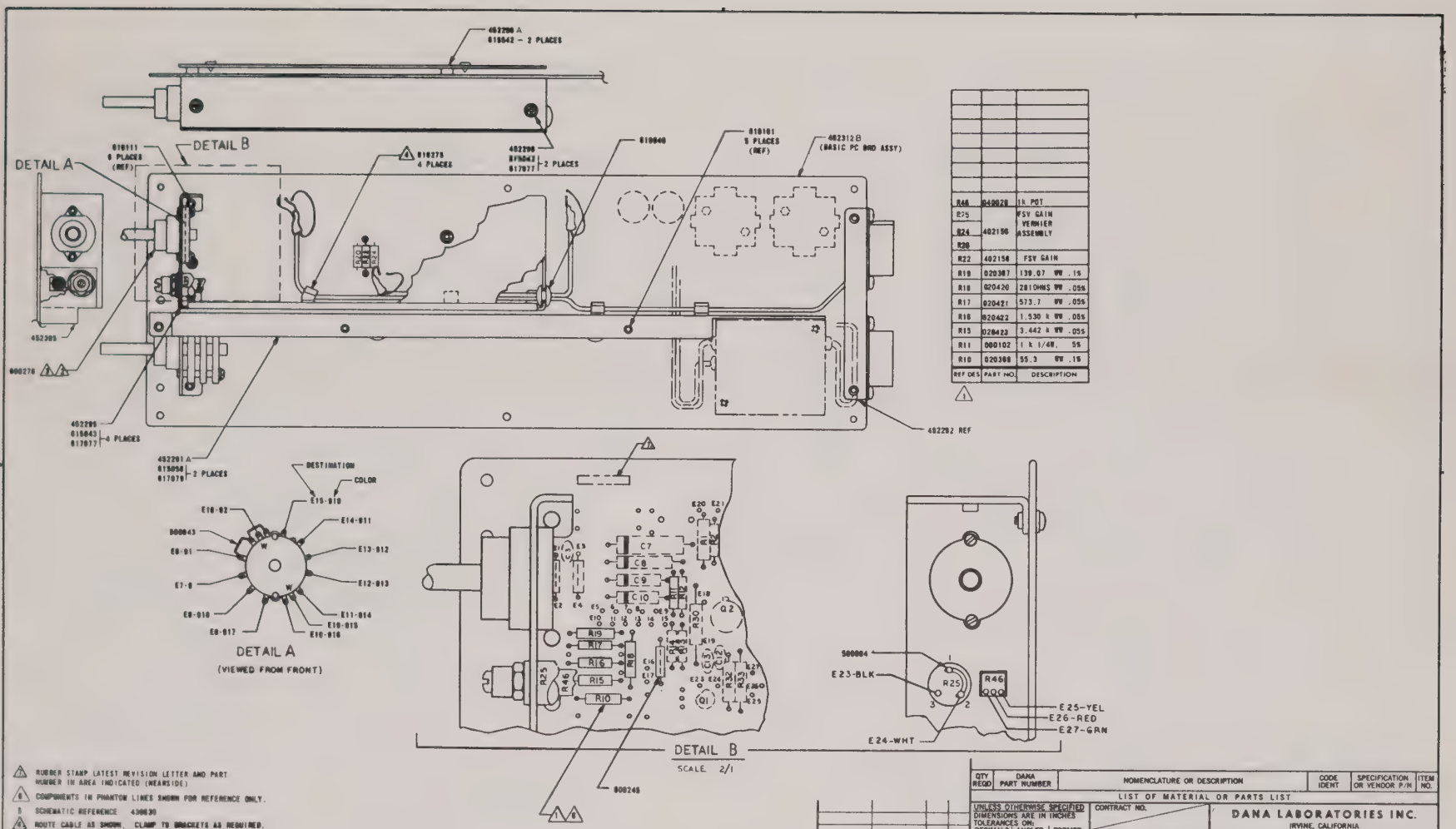
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS .XX ±.03 .XXX ±.010 ANGLES 0° 30' FORMED ANGLES ±2°	CONTRACT NO.	DANA LABORATORIES INC. IRVINE, CALIFORNIA	
MATERIAL	DRAWN	PCB ASSY – MODEL 2850 V2	
FINISH	CHECK		
	DESIGN		
	PROJ ENGR		

NEXT ASSY	USED ON	REF NA	REP FA
	2850 V2		
APPLICATION		QTY REQD	

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402311	

SCALE NONE WT SHEET 8 OF 8

NOTE: UNLESS OTHERWISE SPECIFIED



REF DES	PART NO.	DESCRIPTION
R46	040028	1K POT
R25		FSV GAIN
R24	402156	VERNIER
R26		ASSEMBLY
R22	402156	FSV GAIN
R19	020367	139.07 WW .1%
R18	020420	2810HMS WW .05%
R17	020421	573.7 WW .05%
R16	020422	1.530 k WW .05%
R15	020423	3.442 k WW .05%
R11	000102	1 k 1/4W, 5%
R10	020368	55.3 WW .1%

1. RUBBER STAMP LATEST REVISION LETTER AND PART NUMBER IN AREA INDICATED (NEARSIDE)
2. COMPONENTS IN PHANTOM LINES SHOWN FOR REFERENCE ONLY.
3. SCHEMATIC REFERENCE 430830
4. ROUTE CABLE AS SHOWN. CLAMP TO BRACKETS AS REQUIRED.
5. COAT AREA WITH HUMI SEAL AS REQUIRED AVOIDING BRACKET MOUNTING HOLES MOUNT BRACKET TO PC BOARD
6. MOUNT SWITCH, R25 & R46 TO BRACKET-WIRE PER DETAIL "A". WIRING ON SWITCH SHOULD ROLL OFF ONE SIDE, KEEPING WIRE LENGTH TO A MINIMUM.
7. ADD OPTIONAL COMPONENTS PER DANA WORKMANSHIP STANDARDS

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

NEXT ASSY	USED ON	NA	FA
402391	2850-V3	1	1
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS X .030 .XX .010 .XXX .010 ANGLES 0° 30' FORMED ANGLES ±D

MATERIAL

FINISH

CONTRACT NO.

DRAWN

CHECK

ENGR

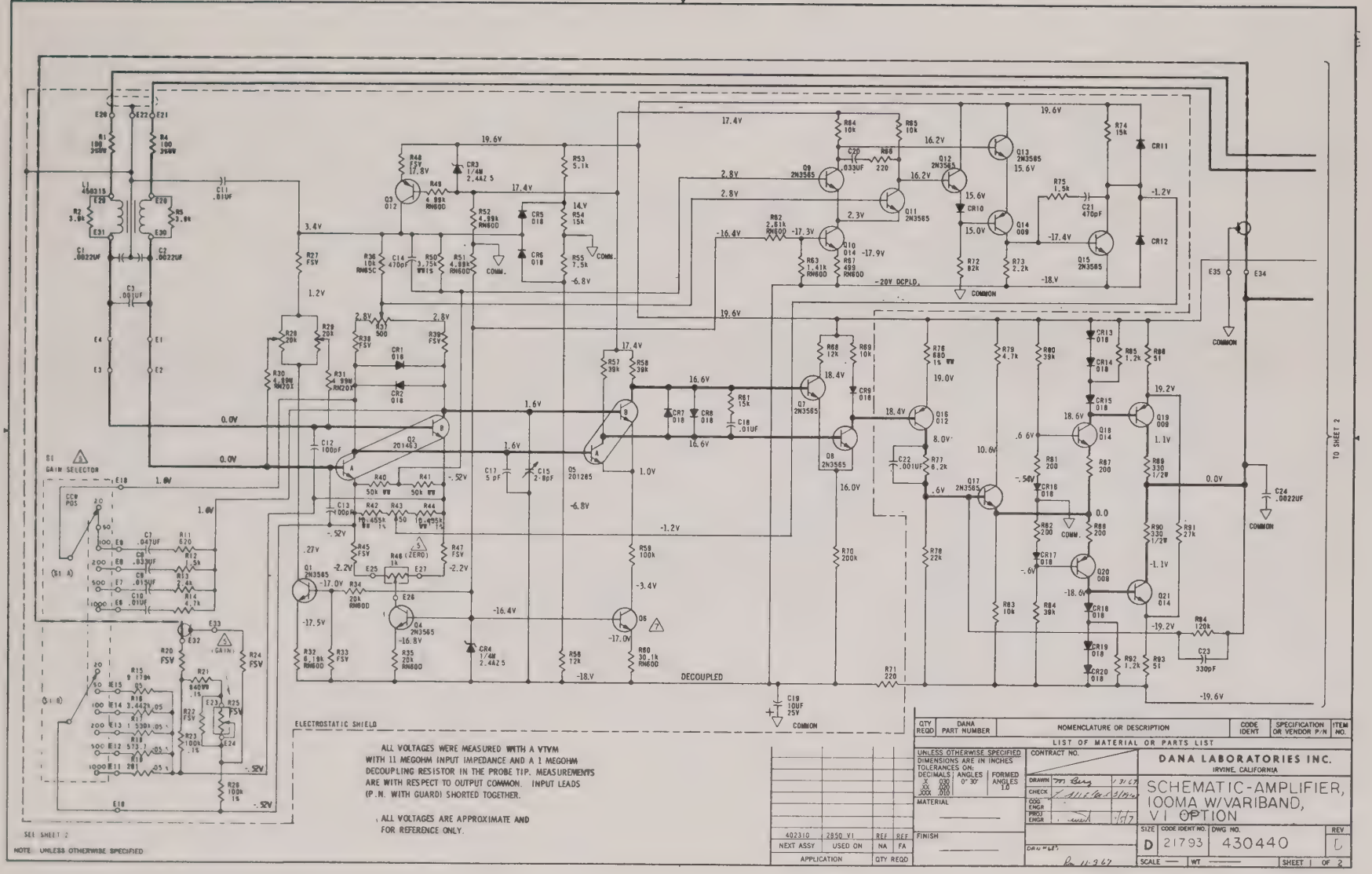
PROJ ENGR

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

P.C.BOARD ASSY-AMP, 100 MA O.P. W/VARIBAND V3 OPTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21703	402392	D

SCALE 1/1 WT SHEET 1 OF 1


ALL VOLTAGES WERE MEASURED WITH A VTVM WITH 11 MEGOHM INPUT IMPEDANCE AND A 1 MEGOHM DECOUPLING RESISTOR IN THE PROBE TIP. MEASUREMENTS ARE WITH RESPECT TO OUTPUT COMMON. INPUT LEADS (P.N. WITH GUARD) SHORTED TOGETHER.
ALL VOLTAGES ARE APPROXIMATE AND FOR REFERENCE ONLY.
ELECTROSTATIC SHIELD
DECOUPLED
COMMON
-20V DCPLD.
GAIN SELECTOR
SEE SHEET 2
NOTE: UNLESS OTHERWISE SPECIFIED
TO SHEET 2

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

402310	2850 V1	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS ANGLES X .030 0° 30' XX .010 XXX .010
FORMED ANGLES 1.0
MATERIAL
FINISH

CONTRACT NO.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

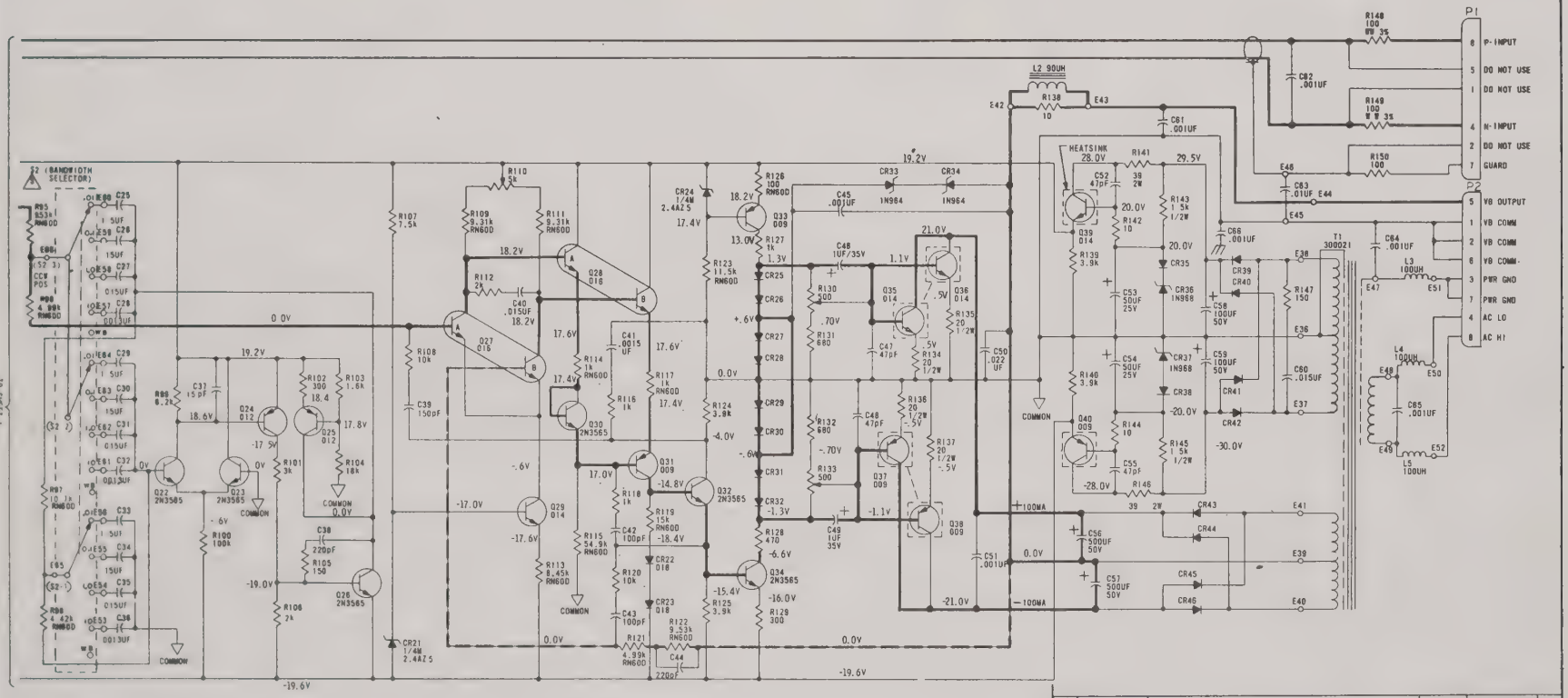
DRAWN	[illegible]	1-31-67
CHECK	[illegible]	3/10/67
COG ENGR		
PROJ ENGR	[illegible]	3/6/67

DRAWER: Ro 11-2-67

SCHEMATIC-AMPLIFIER, 100MA W/VARIBAND, V1 OPTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430440	L

SCALE — WT — SHEET 1 OF 2



TRANSISTOR Q7 IS A SELECTED 014 TRANSISTOR. (P/N 200078)

B "E" NUMBERS DENOTE EYELETS AND CORRESPOND TO POINTS ON PC BRD SEE ASSY DWGS #402312 (BASIC BRD ASSY) AND 402311 (BRD ASSY W/OPTION ADDED)

5 R25(GAIN), R46(ZERO), S1(GAIN SELECTOR) AND S2(BANDWIDTH SELECTOR) ARE FRONT PANEL ADJUSTMENT

4 REFERENCE C16 NOT USED

3 HIGHEST REFERENCE DESIGNATORS USED C80, CR48, L5, Q40, R150

2 ALL DIODES ARE 1N4.

1 ALL RESISTORS ARE IN OHMS 1/4W ± 5% CARBON

NOTE: UNLESS OTHERWISE SPECIFIED

ALL VOLTAGES WERE MEASURED WITH A VTVM WITH 11 MEGOHM INPUT IMPEDANCE AND A 1 MEGOHM DECOUPLING RESISTOR IN THE PROBE TIP. MEASUREMENTS ARE WITH RESPECT TO OUTPUT COMMON. INPUT LEADS (P.N. AND GUARD) SHORTED TOGETHER.

ALL VOLTAGES ARE APPROXIMATE AND FOR REFERENCE ONLY

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P N	ITEM NO

LIST OF MATERIAL OR PARTS LIST

402310	2850 V1	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS X .020, XXX .010; ANGLES 0° 30'; FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

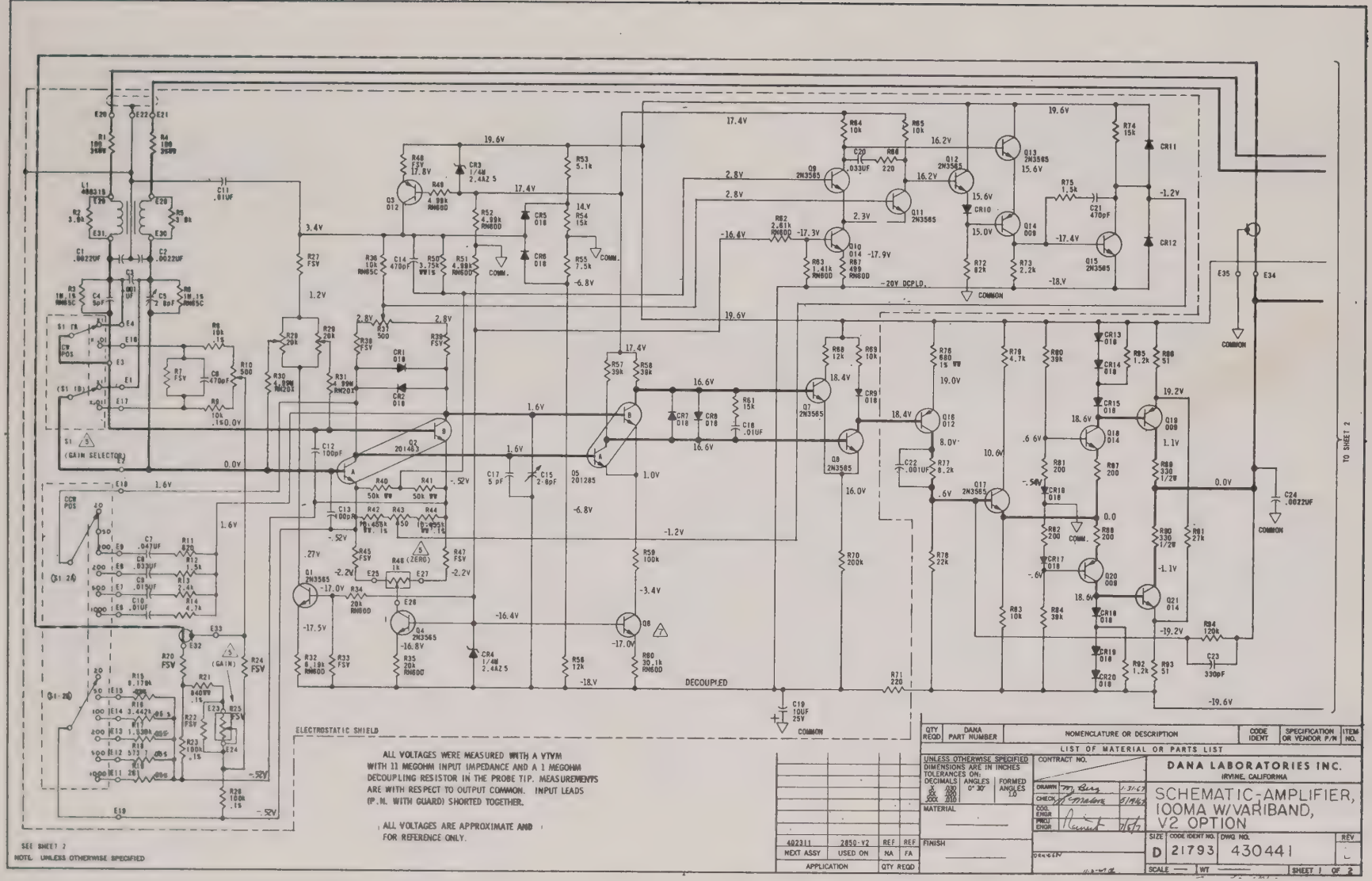
DRAWN	W. Berg	1-19-67
CHECK	[illegible]	5-11-67
COG. ENGR		
PROJ ENGR	[illegible]	1/5/67

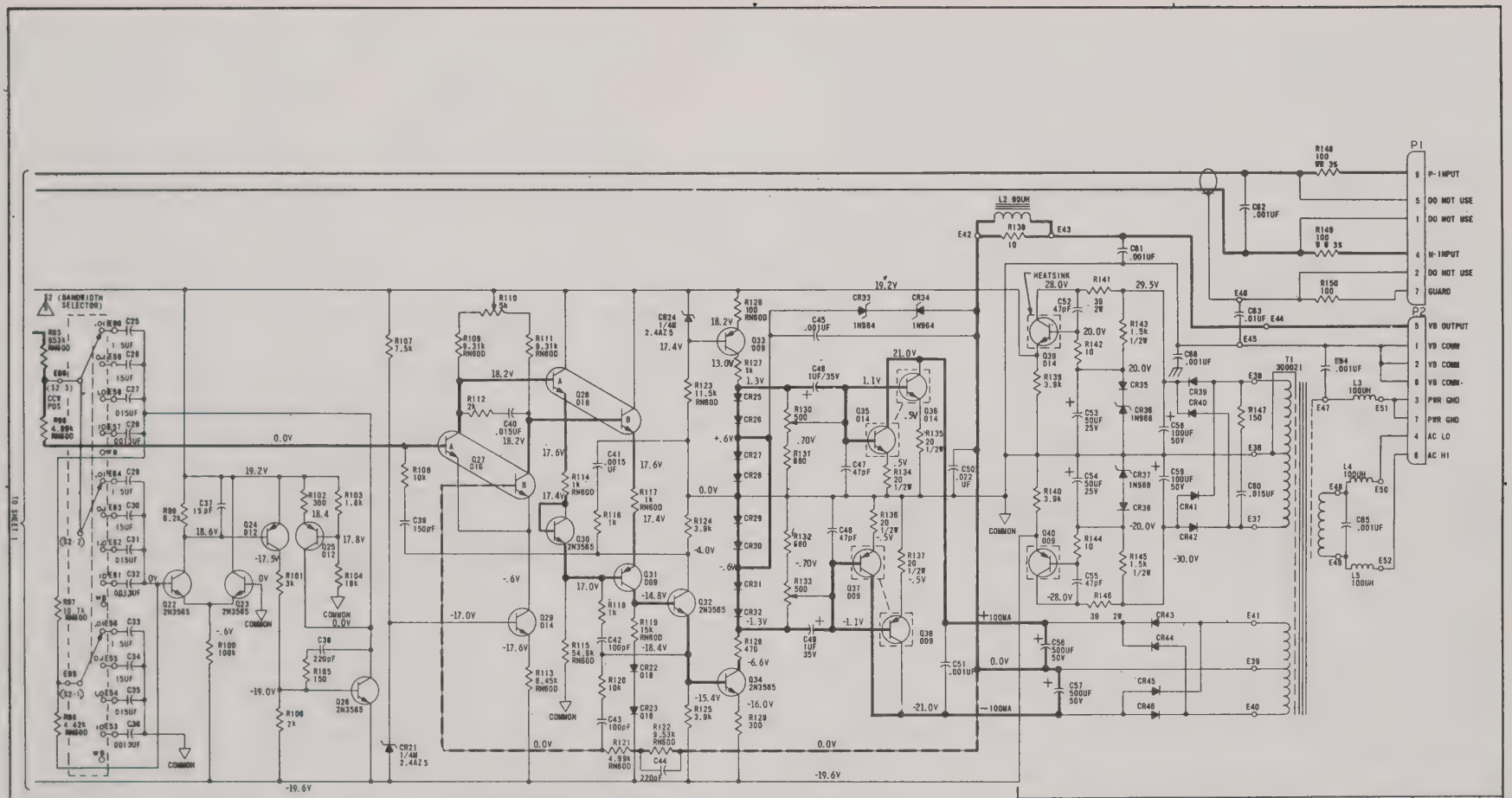
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC-AMPLIFIER, 100MA O.P. W/VARIBAND, V1 OPTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430440	

SCALE — WT — SHEET 2 OF 2


ALL VOLTAGES WERE MEASURED WITH A VTVM WITH 11 MEGOHM INPUT IMPEDANCE AND A 1 MEGOHM DECOUPLING RESISTOR IN THE PROBE TIP. MEASUREMENTS ARE WITH RESPECT TO OUTPUT COMMON. INPUT LEADS (P.N. WITH GUARD) SHORTED TOGETHER.
ALL VOLTAGES ARE APPROXIMATE AND FOR REFERENCE ONLY.
ELECTROSTATIC SHIELD
DECOUPLED
COMMON
-20V DCPLD.
TO SHEET 2
SEE SHEET 2
NOTE: UNLESS OTHERWISE SPECIFIED
QTY REQD
DANA PART NUMBER
NOMENCLATURE OR DESCRIPTION
CODE IDENT
SPECIFICATION OR VENDOR P/N
ITEM NO.
LIST OF MATERIAL OR PARTS LIST
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS ANGLES FORMED ANGLES
CONTRACT NO.
DANA LABORATORIES INC.
IRVINE, CALIFORNIA
DRAWN
CHECK
ENGR
PROJ ENGR
MATERIAL
FINISH
SCHEMATIC-AMPLIFIER, 100MA W/VARIBAND, V2 OPTION
SIZE D
CODE IDENT NO. 21793
DWG NO. 430441
REV L
SCALE
WT
SHEET 1 OF 2
402311 NEXT ASSY
2850-V2 USED ON
REF NA
REF FA
APPLICATION
QTY REQD



1. TRANSISTOR Q7 IS A SELECTED 014 TRANSISTOR. (P/N 200078)
2. "E" NUMBERS DENOTE EYELETS AND CORRESPOND TO POINTS ON PC BRD SEE ASSY DWGS #402312 (BASIC BRD ASSY) AND 402311 (BRD ASSY W/OPTION ADDED)
3. R26(GAIN), R48(ZERO), S1(GAIN SELECTOR) AND S2(BANDWIDTH SELECTOR) ARE FRONT PANEL ADJUSTMENT
4. REFERENCE C18 NOT USED
5. HIGHEST REFERENCE DESIGNATORS USED: C80, CR48, L5, Q40, R150
6. ALL DIODES ARE 914.
7. ALL RESISTORS ARE IN OHMS, 1/4W ± 5%, CARBON

NOTE: UNLESS OTHERWISE SPECIFIED

ALL VOLTAGES WERE MEASURED WITH A VTVM WITH 11 MEGOHM INPUT IMPEDANCE AND A 1 MEGOHM DECOUPLING RESISTOR IN THE PROBE TIP. MEASUREMENTS ARE WITH RESPECT TO OUTPUT COMMON. INPUT LEADS (P.N. AND GUARD) SHORTED TOGETHER.

ALL VOLTAGES ARE APPROXIMATE AND FOR REFERENCE ONLY.

402311	2850-V2	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS: X .030, .XX .010, .XXX .005; ANGLES 0° 30'; FORMED ANGLES 1°

MATERIAL

FINISH

CONTRACT NO.

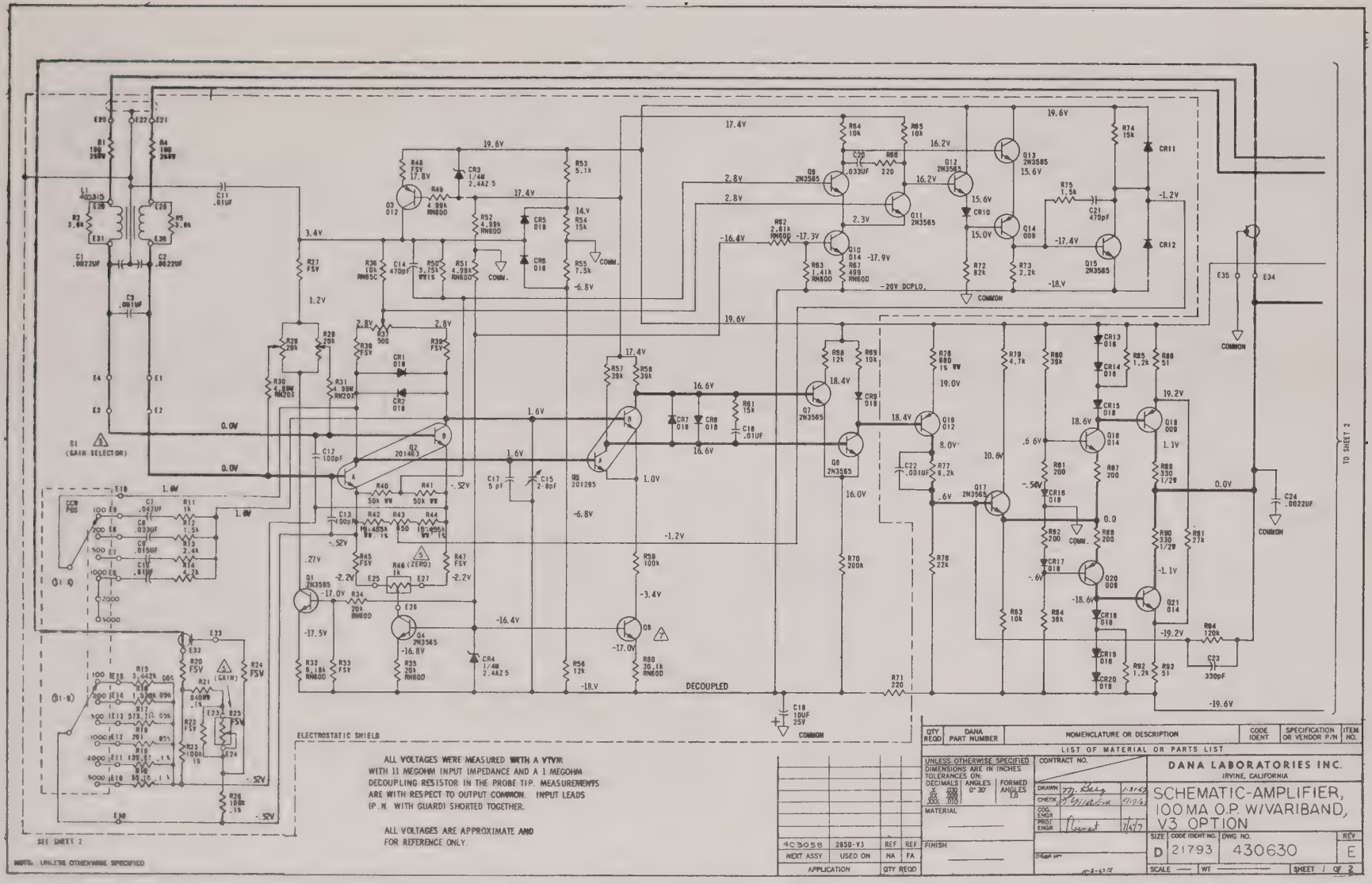
DRAWN	W. Berg	1-31-67
CHECK	J. Malone	2/14/67
COG. ENGR		
PROJ. ENGR		7/5/67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC-AMPLIFIER, 100 MA O.P. W/VARIBAND, V2 OPTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430441	D

SCALE — WT — SHEET 2 OF 2


ALL VOLTAGES WERE MEASURED WITH A VTVM WITH 11 MEGOHM INPUT IMPEDANCE AND A 1 MEGOHM DECOUPLING RESISTOR IN THE PROBE TIP. MEASUREMENTS ARE WITH RESPECT TO OUTPUT COMMON. INPUT LEADS (P.N. WITH GUARD) SHORTED TOGETHER.
ALL VOLTAGES ARE APPROXIMATE AND FOR REFERENCE ONLY.
ELECTROSTATIC SHIELD
DECOUPLED
COMMON
TO SHEET 2
SEE SHEET 2
NOTE: UNLESS OTHERWISE SPECIFIED
B1 (GAIN SELECTOR)
(S1-A)
(S1-B)
(GAIN)
(ZERO)

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

4C3058	2850-V3	REF	REF
NEXT ASSY	USED ON	NA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS | ANGLES | FORMED ANGLES
X .030 | 0° 30' | 1.0
XX .020
XXX .010
MATERIAL
FINISH

CONTRACT NO.

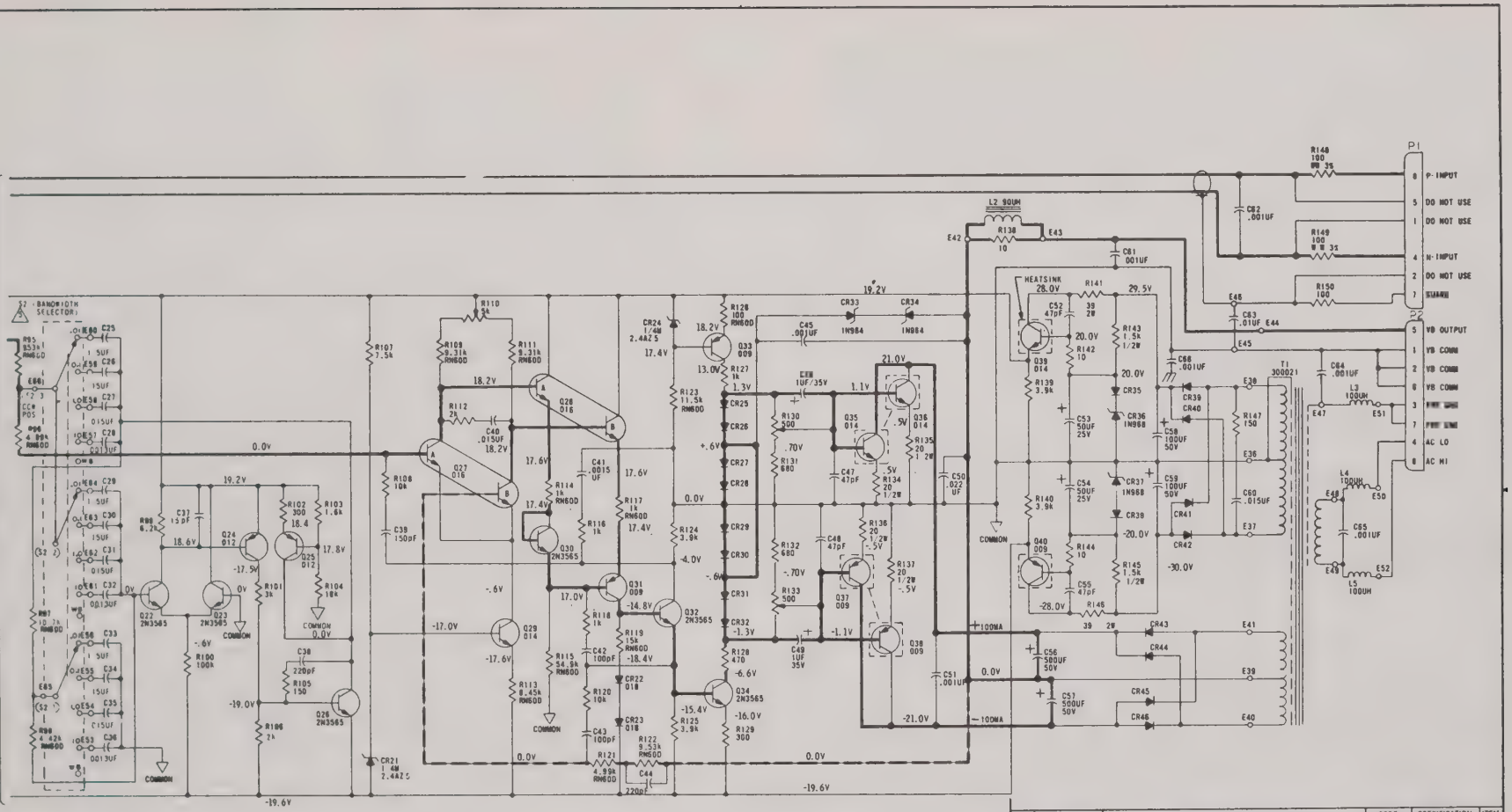
DRAWN	W. Berg	1-31-67
CHECK	D. Gilmore	2/1/67
COG. ENGR		
PROJ. ENGR		
		2/16/67

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

SCHEMATIC-AMPLIFIER, 100 MA O.P. W/VARIBAND, V3 OPTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430630	E

SCALE — | WT — | SHEET 1 OF 2



1. ALL RESISTORS ARE IN OHMS 1 4W ± 5% CARBON
2. ALL DIODES ARE SD4
3. HIGHEST REFERENCE DESIGNATORS USED
   C86 CR46 L5 Q40 R150
4. REFERENCE C18 NOT USED
5. R25(GAIN) R48(ZERO) S1(GAIN SELECTOR) AND S2(BANDWIDTH SELECTOR) ARE FRONT PANEL ADJUSTMENT
6. TRANSISTOR Q7 IS A SELECTED Q14 TRANSISTOR (P N 280078)

NOTE UNLESS OTHERWISE SPECIFIED

8 "E" NUMBERS DENOTE EYELETS AND CORRESPOND TO POINTS ON PC BRD SEE ASSY DWGS 402312 (BASIC BRD ASSY) AND 402311 (BWB ASSY & OPTION ADDED)

ALL VOLTAGES WERE MEASURED WITH A VTVM WITH 11 MEGOHM INPUT IMPEDANCE AND A 1 MEGOHM DECOUPLING RESISTOR IN THE PROBE TIP. MEASUREMENTS ARE WITH RESPECT TO OUTPUT COMMON. INPUT LEADS (P.N. AND GUARD) SHORTED TOGETHER.

ALL VOLTAGES ARE APPROXIMATE AND FOR REFERENCE ONLY.

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

402055	2850-V3	REF	REF
NEXT ASSY	USED ON	MA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS X .030 XX .010 XXX .010 ANGLES 0° 30' FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN 77 K 3 1-31-77

CHECK

COG ENGR

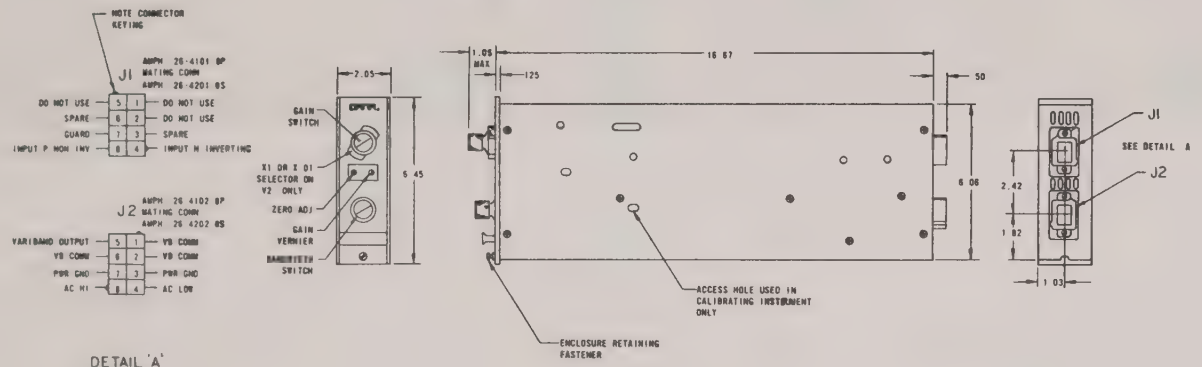
PROJ ENGR

DANA LABORATORIES INC.
IRVINE CALIFORNIA

SCHEMATIC-AMPLIFIER, 100 MA O.P. W/VARIBAND, V3 OPTION

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430630	E

SCALE — WT — SHEET 2 OF 2



DETAIL 'A'

WIRING TYPICAL OF DANA CORD SET NO 402468 AND DANA MODEL 2008 1 & 2008 2 ENCLOSURE

1. OUTLINE TYPICAL FOR 2850 OPTIONS V1, V2, & V3

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			
402391	2850 V3	REF	REF		
402308	2850 V2	REF	REF		
402307	2829 V1	REF	REF		
NEXT ASSY	USED ON	NA	FA		
APPLICATION		QTY REQD			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: DECIMALS X .030, XX .010, XXX .005; ANGLES 0° 30'; FORMED ANGLES ±0

MATERIAL

FINISH

CONTRACT NO.

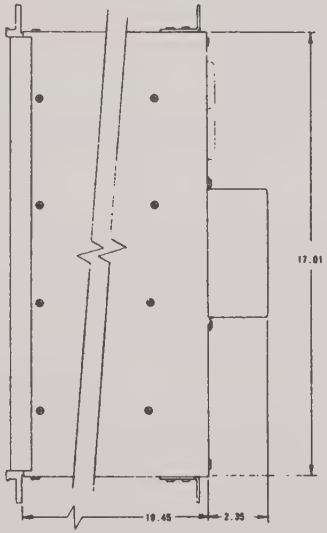
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

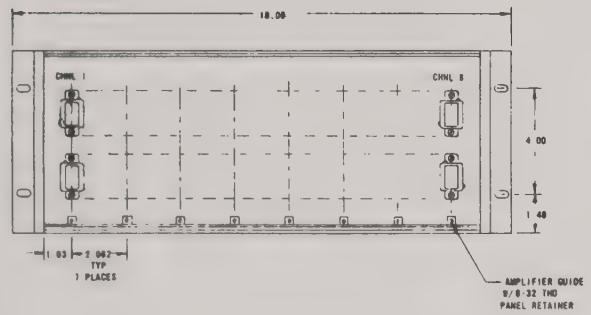
DRAWN G. WILSON 12/4/67
CHECK W.E. Sutton 12/4/67
DSG ENGR
PROJ ENGR Raymond Bailey

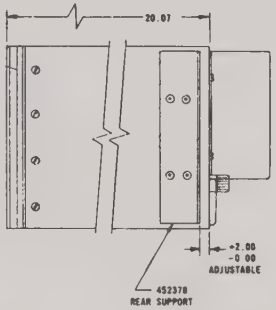
OUTLINE DIMENSIONAL
AMPLIFIER MODEL 2850

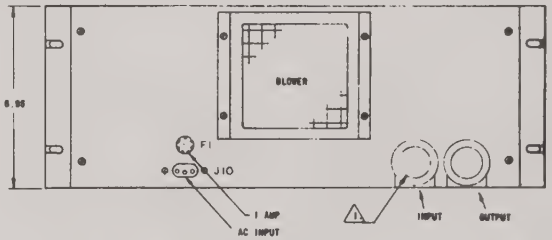
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	452401	A

SCALE 1/2 | WT | SHEET 1 OF 1









⚠ ENCLOSURE WIRING PER DANA DRAWING # 430500

NOTE: UNLESS OTHERWISE SPECIFIED

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

402388	2801-1	REF	REF
NEXT ASSY	USED ON	MA	FA
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .030, .XX .010, .XXX .010 | ANGLES 0° 30' | FORMED ANGLES ±1°
MATERIAL
FINISH

CONTRACT NO.

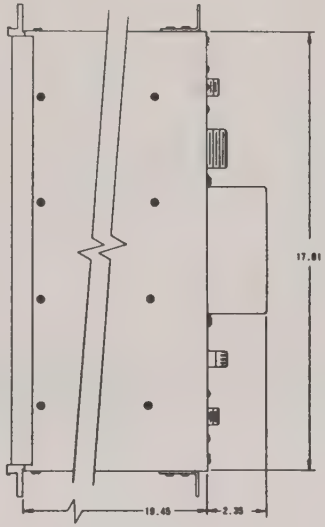
DRAWN G WILSON 8/27/67
CHECK
ENG APPR
PROJ ENGR 6/27/67

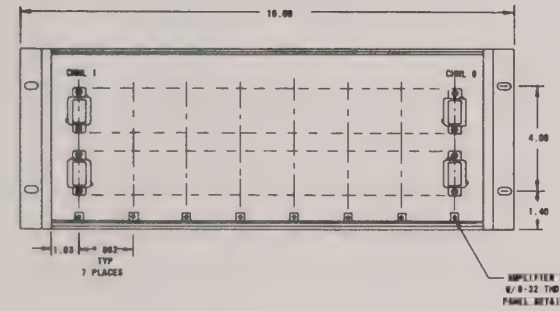
DANA LABORATORIES INC.
IRVINE, CALIFORNIA

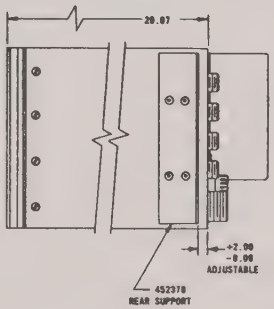
OUTLINE DIMENSIONAL
ENCLOSURE
MODEL 2808-1

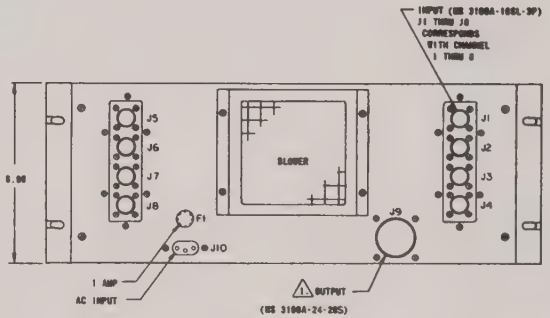
SIZE D | DRAWING NO. 21793 | DWG NO. 452402

SCALE 1/2 | WT | SHEET 1 OF 1









QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
LIST OF MATERIAL OR PARTS LIST					

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .00, XX .020, XXX .010
ANGLES 0° 30'
FORMED ANGLES TO
MATERIAL
FINISH

CONTRACT NO.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

DRAWN	G WILSON	6/26/67
CHECK	H.F. Schuessler	21 JUNE 67
DSG. ENGR		
PROJ. ENGR		6/28/67

OUTLINE DIMENSIONAL
ENCLOSURE
MODEL 2808-2

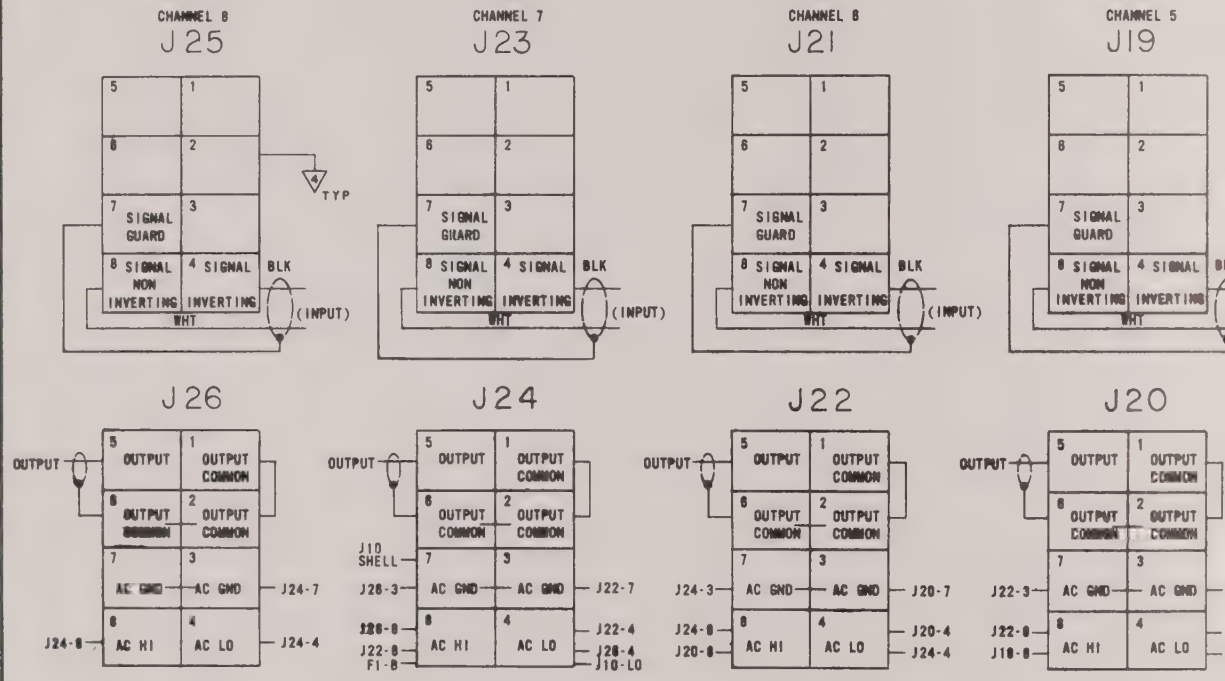
SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	452403	

SCALE 1/2 | WT | SHEET 1 OF 1

402371	II 8 D 8 - II	REF	REF
NEXT ASSY	USED ON	MA	FA
APPLICATION		QTY REQD	

⚠ ENCLOSURE WIRING PER DANA DRAWING # 438681.

NOTE: UNLESS OTHERWISE SPECIFIED



PIN 2 TIED TO GROUND LUG MOUNTED ON CONNECTORS J11, 13, 15, 17, 19, 21, 23 AND J25 USING [illegible] WIRE.

3. INTERCONNECTIONS ON CONNECTORS USING 50D004 WIRE AND 501378 SLEEVING AS REQUIRED.

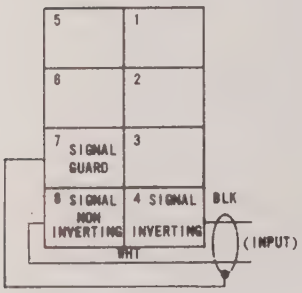
ALL AC POWER WIRING TO BE TWISTED.

1. WIRE PER DANA WORKMANSHIP AND PROCEDURE STANDARDS.

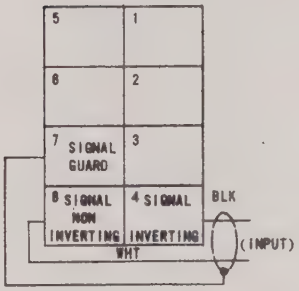
NOTE: UNLESS OTHERWISE SPECIFIED

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	REVISED PER E.O. 2048	12/8/67	
B	REVISED PER E.O. 2118, REROUTE POWER LINE TO J24 WAS TO J12	12/8/67 PRCHAL	12/9/67
C	REVISED PER E.O. 2199	F.A. 12/26/67	1/2/68

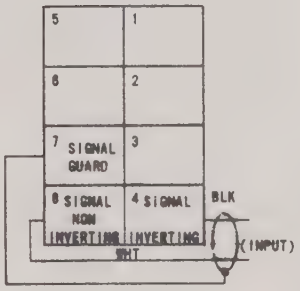
CHANNEL 4
J17



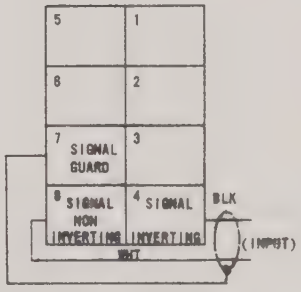
CHANNEL 3
J15



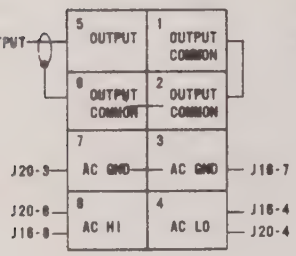
CHANNEL 2
J13



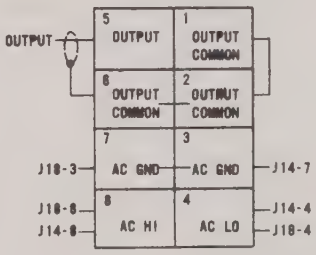
CHANNEL 1
J11



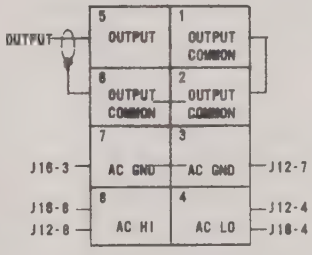
J18



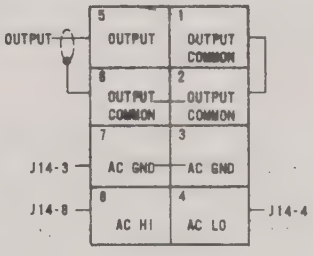
J16



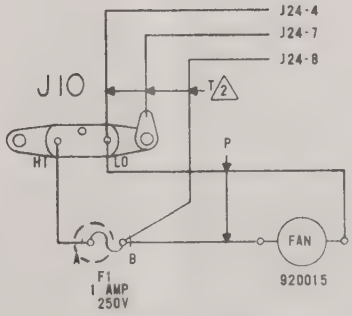
J14



J12



J10



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .030, XX .010, XXX .005
ANGLES 0° 30'
FORMED ANGLES 1.0

CONTRACT NO.

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

DRAWN	ABBOTT	11/9/67
CHECK		12 APR 67
COG. ENGR		
PROJ ENGR		

MATERIAL

FINISH

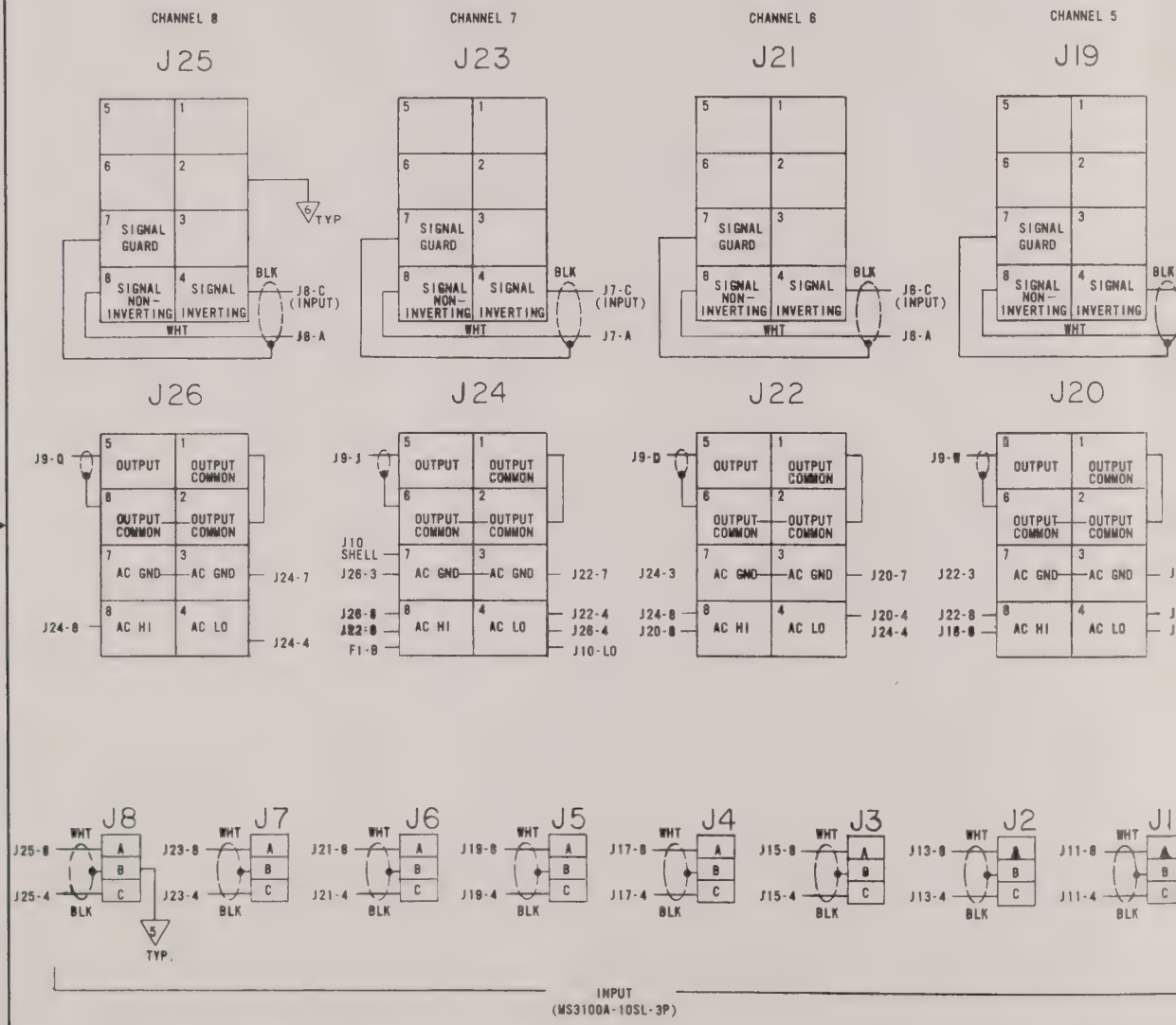
WIRING DIAGRAM — 2808 ENCLOSURE, OPT. 1

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430590	C

SCALE NONE WT

SHEET 1 OF 1

430589	2808-1	NEXT ASSY	USED ON
APPLICATION		QTY REQD	NA / FA



6. PIN 2 TIED TO GROUND LUG MOUNTED ON CONNECTORS J11, 13, 15, 17, 19, 21, 23, AND J25 USING 524006 WIRE.

5. PIN B ON J1 THRU J8 TO BE TIED TO GROUND LUG MOUNTED ON CONN SHELL USING 500002 WIRE.

4. INTERCONNECTIONS ON CONNECTORS USING 500004 WIRE AND 501376 SLEEVING AS REQUIRED.

3. ALL AC POWER WIRING TO BE TWISTED.

2. ROUTE AND TIE HARNESSES AND OTHER WIRING PERMITTING REAR PANEL TO OPEN APPROXIMATELY 120°. USE CLAMPS AS REQUIRED TO KEEP CABLES CLEAR OF OPENING ON CONNECTOR MOUNTING BRACKET.

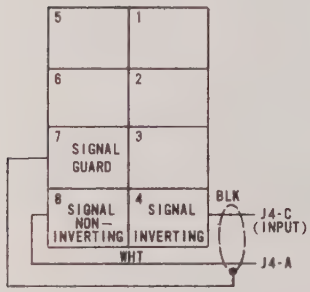
1. WIRE PER DANA WORKMANSHIP AND PROCEDURE STANDARDS

NOTE: UNLESS OTHERWISE SPECIFIED

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	REVISED PER EO 2049	18 NOV 1967	
B	REVISED PER E.O. 2111 REROUTE POWER LINE TO J-24 WAS TO J12	12/8/67 PRELIM	
C	REVISED PER E.O. 2188	12 DEC 67	

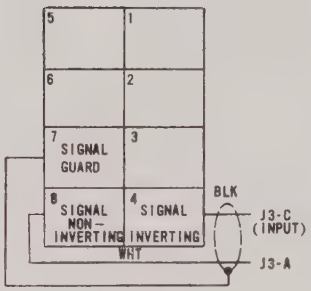
CHANNEL 4

J17



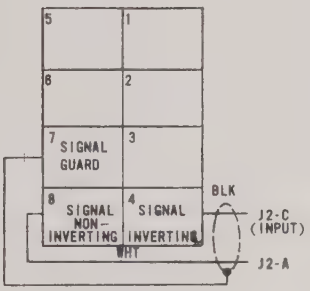
CHANNEL 3

J15



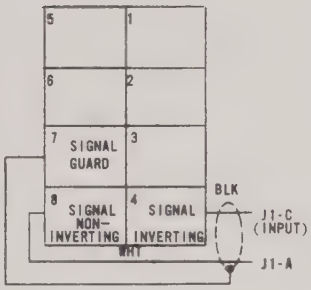
CHANNEL 2

J13

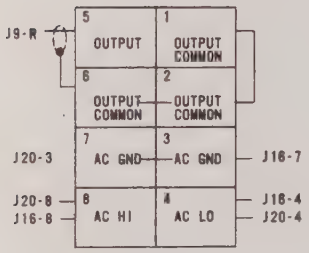


CHANNEL 1

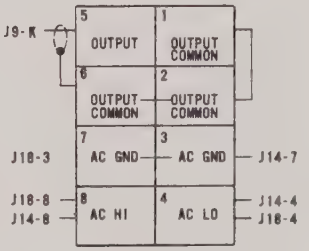
J11



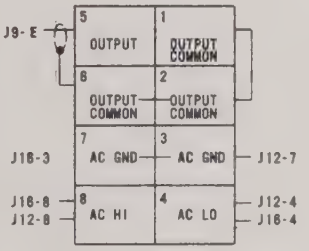
J18



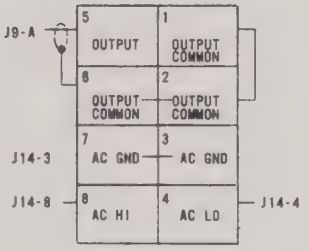
J16



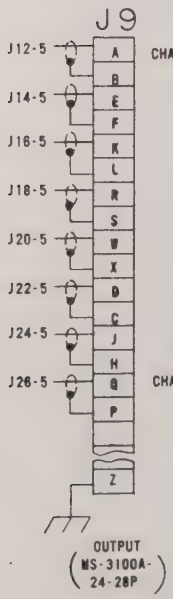
J14



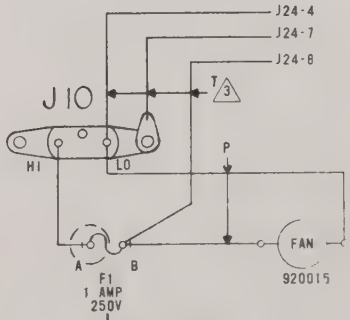
J12



J9



J10



QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.
		LIST OF MATERIAL OR PARTS LIST			

402371	2808-2	REF	REF	
NEXT ASSY	USED ON	NA	FA	
APPLICATION		QTY REQD		

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS: X .030, XX .020, XXX .010
ANGLES 0° 30'
FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN ABBOTT 12/6/67
CHECK
COG. ENGR
PROJ. ENGR

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

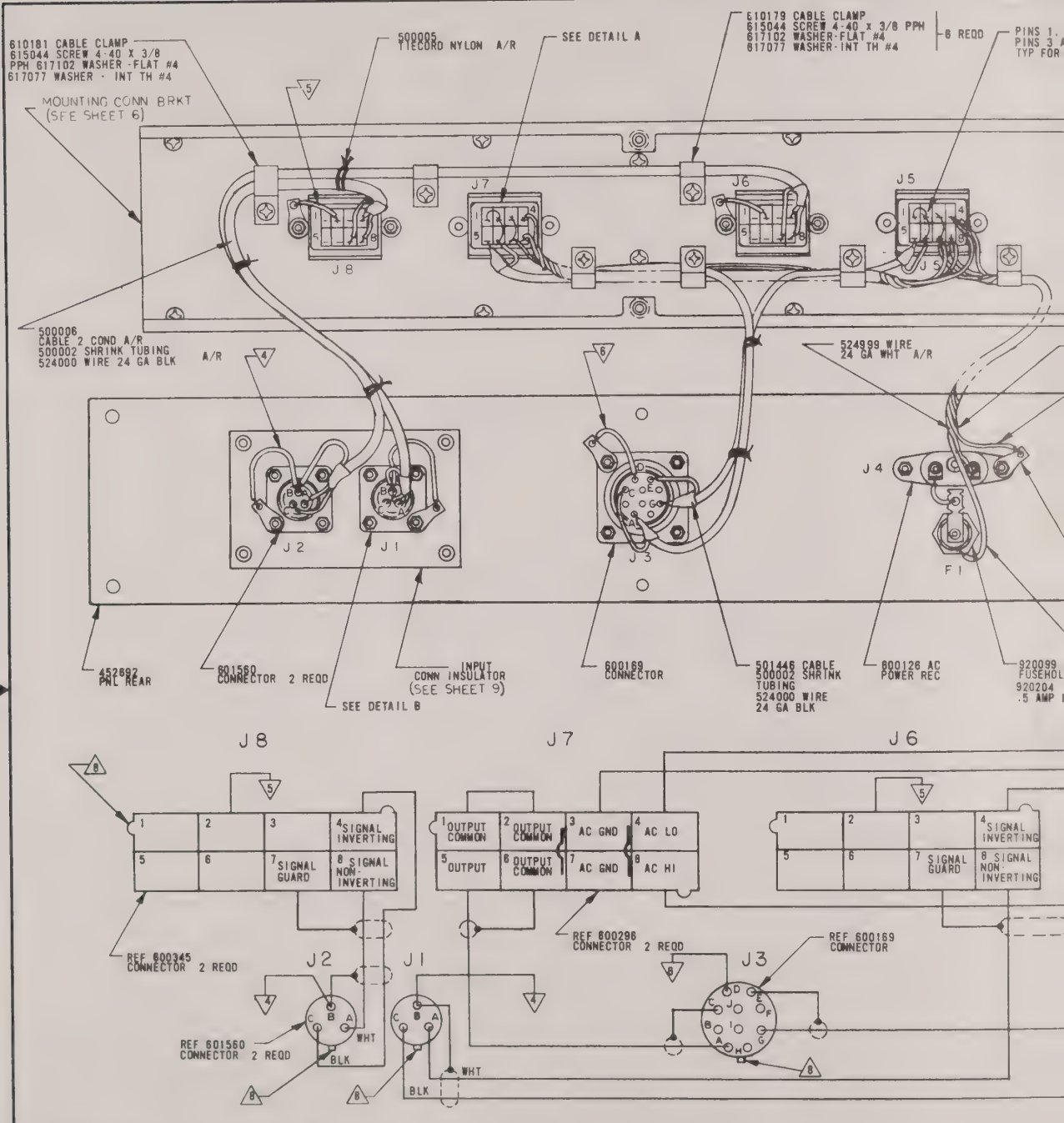
WIRING DIAGRAM — 2808 ENCLOSURE, OPT. 2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	430591	C

SCALE NONE WT SHEET 1 OF 1

DAN # 219
Rec 11-4-67

Rev A 11-14-67
Rev B 12-8-67



7. RUBBER GROMMET TO BE CUT OFF AS SHOWN BEFORE ASSEMBLY
6. PIN D ON J3 TO BE TIED TO GROUND LUG MOUNTED ON CONNECTOR SHELL USING 500043 WIRE
5. PIN 2 ON J8 TO BE TIED TO GROUND LUG MOUNTED ON CONNECTOR SHELL USING 500043 WIRE
4. PIN B ON J1 TO BE TIED TO GROUND LUG MOUNTED ON CONNECTOR SHELL USING 500043 WIRE
3. ALL A.C. POWER WIRING TO BE TWISTED
2. ROUTE AND TIE HARNESSES AND OTHER WIRING APPROX AS SHOWN TO PERMIT REAR PANEL TO LAY OPEN FOR WIRING
1. WIRE PER DANA WORKMANSHIP AND PROCEDURE STANDARDS

9. LOCKWASHER NOT USED WITH GROUND LUG P/N 600032
8. CONNECTOR SHELLS ARE KEYED AS INDICATED

NOTE: UNLESS OTHERWISE SPECIFIED

REVISIONS				
LTR	DESCRIPTION	DR	CHK	APPD
	SEE SHEET 1			

D 6 JUMPERED
JUMPERED
ND J7

REF 452692 PNL - REAR

REF (SEE SHEET 9) INPUT CONN INSULATOR

REF 600032 GROUND LUG 2 REQD (9)

(9)

.25 (7)

601474 CABLE CLAMP 2 REQD

REF 601560 CONNECTOR 2 REQD

617004 #4 NUT HEX 8 REQD

617077 #4 WASHER INT TH 11 REQD

DETAIL B

615044 SCREW PPH 4-40 x 3/8 18 REQD

524090 WIRE 24 GA BLK-WHT-BLK A/R

600032 #4 SOLDER LUG 6 REQD (9)

524000 WIRE 24 GA BLK

600296 CONNECTOR AMP 26-4201-8S

600345 CONNECTOR AMP 26-4202-8S

615046 SCREW PPH 4-40 x 1/2 4 REQD

617077 #4 WASHER INT TH 2 REQD

452289 CONN INSULATOR 2 REQD

MOUNTING CONN BRKT (SEE SHEET 6)

617102 #4 FLAT WASHER 2 REQD

610127 #4 WASHER NYLON SHOULDER 2 REQD

617077 #4 INT TH WASHER

617004 #4 NUT HEX 2 REQD

REF 600032 GROUND LUG (9)

DETAIL A

TOP VIEW
TYP 2 PLACES
(J5-J6; J7-J8)

J5

OUTPUT COMMON	2 OUTPUT COMMON	3 AC GND	4 AC LO
OUTPUT	6 OUTPUT COMMON	7 AC GND	8 AC HI

WHT

J4

HI LO

BLK-WHT-BLK

F1

T (3)

BLK

REF 920099 FUSE HOLDER

REF 600126
C POWER REC

QTY REQD	DANA PART NUMBER	NOMENCLATURE OR DESCRIPTION	CODE IDENT	SPECIFICATION OR VENDOR P/N	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS X .030 XX .020 XXX .010
ANGLES 0° 30'
FORMED ANGLES 1.0

MATERIAL

FINISH

CONTRACT NO.

DRAWN R Prichal
CHECK
DESIGN R Prichal
PROJ ENGR

DANA LABORATORIES INC.
IRVINE, CALIFORNIA

ENCLOSURE ASSY - MODEL 2802-2

SIZE	CODE IDENT NO.	DWG NO.	REV
D	21793	402948	B

SCALE WT SHEET 3 OF 12

NEXT ASSY	USED ON	NA	FA
	2802-2		
APPLICATION		QTY REQD	

PARTS LIST

ASSEMBLY 402310 **PC Board Assembly - Amp, 100 MA O.P. w/Variband, V1 Option** A

REF. DESIG.	PART NO.	DESCRIPTION			
CR01	211083	DIODE SILICO 018	1	DANA	211083
CR02	211083	DIODE SILICO 018	1	DANA	211083
CR03	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR04	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR05	211083	DIODE SILICO 018	1	DANA	211083
CR06	211083	DIODE SILICO 018	1	DANA	211083
CR07	211083	DIODE SILICO 018	1	DANA	211083
CR08	211083	DIODE SILICO 018	1	DANA	211083
CR09	211083	DIODE SILICO 018	1	DANA	211083
CR10	210004	DIODE SILICO SD4		DIODES IN SD4	
CR11	210004	DIODE SILICO SD4		DIODES IN SD4	
CR12	210004	DIODE SILICO SD4		DIODES IN SD4	
CR13	211083	DIODE SILICO 018	1	DANA	211083
CR14	211083	DIODE SILICO 018	1	DANA	211083
CR15	211083	DIODE SILICO 018	1	DANA	211083
CR16	211083	DIODE SILICO 018	1	DANA	211083
CR17	211083	DIODE SILICO 018	1	DANA	211083
CR18	211083	DIODE SILICO 018	1	DANA	211083
CR19	211083	DIODE SILICO 018	1	DANA	211083
CR20	211083	DIODE SILICO 018	1	DANA	211083
CR21	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR22	211083	DIODE SILICO 018	1	DANA	211083
CR23	211083	DIODE SILICO 018	1	DANA	211083
CR24	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR25	210004	DIODE SILICO SD4		DIODES IN SD4	
CR26	210004	DIODE SILICO SD4		DIODES IN SD4	
CR27	210004	DIODE SILICO SD4		DIODES IN SD4	
CR28	210004	DIODE SILICO SD4		DIODES IN SD4	
CR29	210004	DIODE SILICO SD4		DIODES IN SD4	
CR30	210004	DIODE SILICO SD4		DIODES IN SD4	
CR31	210004	DIODE SILICO SD4		DIODES IN SD4	
CR32	210004	DIODE SILICO SD4		DIODES IN SD4	
CR33	220016	DIODE SILICO ZENER 1N964B		MOTOROLA 1N964B	
CR34	220016	DIODE SILICO ZENER 1N964B		MOTOROLA 1N964B	
CR35	210004	DIODE SILICO SD4		DIODES IN SD4	
CR36	220011	DIODE SILICO ZENER 1N968A	1	MOTOROLA 1N968A	
CR37	220011	DIODE SILICO ZENER 1N968A	1	MOTOROLA 1N968A	
CR38	210004	DIODE SILICO SD4		DIODES IN SD4	

PARTS LIST

ASSEMBLY 402310 **PC Board Assembly - Amp, 100 MA O.P. w/Variband, V1 Option** A

REF. DESIG.	PART NO.	DESCRIPTION						
CR39	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR40	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR41	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR42	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR43	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR44	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR45	210004	DIODE SILICO	SD4			DIODES IN SD4		
CR46	210004	DIODE SILICO	SD4			DIODES IN SD4		
C01	121092	CAP MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22	
C02	121092	CAP MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22	
C03	101174	CAP CERAM	.001 MFD	500 V	10%1	AEROVOX	SCD3X5F	
C07	121093	CAP MYLAR	.047 MFD	100 V	10%1	CDE	WMF1S47	
C08	121091	CAP MYLAR	.033 MFD	100 V	10%1	CDE	WMF1S33	
C09	121090	CAP MYLAR	.015 MFD	100 V	10%1	CDE	WMF1S15	
C10	121088	CAP MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1	
C11	121088	CAP MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1	
C12	101145	CAP CERAM	100 PFD	500 V	10%1	AEROVOX	SCD1X5F	
C13	101145	CAP CERAM	100 PFD	500 V	10%1	AEROVOX	SCD1X5F	
C14	101641	CAP CERAM	470 PFD	500 V	10%1	AEROVOX	SCD1X5F	
C15	130004	CAP CERAM	2-8 PFD	500 V	10%	ERIE	538-00289R	
C17	100009	CAP CERAM	5 PFD	500 V	10%	AEROVOX	TCD-N750	
C18	121088	CAP MYLAR	.01 MFD	100 V	10%	CDE	WMF1S1	
C19	111262	CAP ELECT	10 MFD	25 V	20%1	SPRAGUE	TE1204	
C20	121091	CAP MYLAR	.033 MFD	100 V	10%1	CDE	WMF1S33	
C21	101641	CAP CERAM	470 PFD	500 V	10%1	AEROVOX	SCD1X5F	
C22	101174	CAP CERAM	.001 MFD	500 V	10%1	AEROVOX	SCD3X5F	
C23	101098	CAP CERAM	330 PFD	500 V	10%1	AEROVOX	SCD1X5F	
C24	121092	CAP MYLAR	.0022 MFD	100 V	10%	CDE	WMF1D22	
C25	120129	CAP MYLAR	1.5 MFD	100 V	5%	IMB	XT2B155J	
C26	120130	CAP MYLAR	.15 MFD	100 V	5%	IMB	XT2B154J	
C27	120131	CAP MYLAR	.015 MFD	100 V	5%	IMB	XT2B153J	
C28	120132	CAP MYLAR	.0013 MFD	100 V	5%	IMB	XT2B132J	
C29	120129	CAP MYLAR	1.5 MFD	100 V	5%	IMB	XT2B155J	
C30	120130	CAP MYLAR	.15 MFD	100 V	5%	IMB	XT2B154J	
C31	120131	CAP MYLAR	.015 MFD	100 V	5%	IMB	XT2B153J	
C32	120132	CAP MYLAR	.0013 MFD	100 V	5%	IMB	XT2B132J	
C33	120129	CAP MYLAR	1.5 MFD	100 V	5%	IMB	XT2B155J	
C34	120130	CAP MYLAR	.15 MFD	100 V	5%	IMB	XT2B154J	

PARTS LIST

ASSEMBLY 402310 **PC Board Assembly - Amp, 100 MA O.P. w/Variband, V1 Option** A

REF. DESIG.	PART NO.	DESCRIPTION
C35	120131	CAP MYLAR .015 MFD 100 V 5% IMB XT2B153J
C36	120132	CAP MYLAR .0013 MFD 100 V 5% IMB XT2B132J
C37	100013	CAP CERAM 15 PFD 500 V 10% AEROVOX TCD-N750
C38	101175	CAP CERAM 220 PFD 500 V 10%1 AEROVOX SCD1X5F
C39	101642	CAP CERAM 150 PFD 500 V 10%1 AEROVOX SCD2X5F
C40	121090	CAP MYLAR .015 MFD 100 V 10%1 CDE WMF1S15
C41	121473	CAP MYLAR .0015 MFD 100 V 10%1 CDE WMF1S47
C42	101145	CAP CERAM 100 PFD 500 V 10%1 AEROVOX SCD1X5F
C43	101145	CAP CERAM 100 PFD 500 V 10%1 AEROVOX SCD1X5F
C44	101175	CAP CERAM 220 PFD 500 V 10%1 AEROVOX SCD1X5F
C45	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
C46	111095	CAP ELECT 1 MFD 25 V 20%1 SPRAGUE TE1200
C47	101182	CAP CERAM 47 PFD 500 V 10%1 AEROVOX TCD-N750
C48	101182	CAP CERAM 47 PFD 500 V 10%1 AEROVOX TCD-N750
C49	111095	CAP ELECT 1 MFD 25 V 20%1 SPRAGUE TE1200
C50	121468	CAP MYLAR .022 MFD 100 V 10%1 CDE WMF1S22
C51	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
C52	101182	CAP CERAM 47 PFD 500 V 10%1 AEROVOX TCD-N750
C53	110060	CAP ELECT 50 MFD 25 V SPRAGUE TE1209
C54	110060	CAP ELECT 50 MFD 25 V SPRAGUE TE1209
C55	101182	CAP CERAM 47 PFD 500 V 10%1 AEROVOX TCD-N750
C56	110062	CAP ELECT 500 MFD 50 V SPRAGUE 39D507G050L4
C57	110062	CAP ELECT 500 MFD 50 V SPRAGUE 39D507G050L4
C58	110061	CAP ELECT 100 MFD 50 V SPRAGUE 39D107G050EJ4
C59	110061	CAP ELECT 100 MFD 50 V SPRAGUE 39D107G050EJ4
C60	121090	CAP MYLAR .015 MFD 100 V 10%1 CDE WMF1S15
C61	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
C62	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
C63	100017	CAP CERAM .01 MFD 200 V 10% SPRAGUE TH-S10
C64	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
C65	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
C66	101174	CAP CERAM .001 MFD 500 V 10%1 AEROVOX SCD3X5F
Q01	200043	TRANS SILICO NPN 2N3565 FAIRCHILD 2N3565
Q02	402718	ASSY FSV 2850 V1 DANA 402718
Q03	200022	TRANS SILICO PNP 012 DANA 200022
Q04	200043	TRANS SILICO NPN 2N3565 FAIRCHILD 2N3565
Q05	201285	TRANS DUAL NPN 016S DANA 201285
Q06	200078	TRANS SILICO NPN FSV DANA 200078

PARTS LIST

ASSEMBLY 402310 **PC Board Assembly - Amp, 100MA O.P. w/Variband, V1 Option** A

REF. DESIG.	PART NO.	DESCRIPTION					
Q07	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q08	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q09	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q10	200035	TRANS SILICO NPN	014			DANA	200035
Q11	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q12	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q13	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q14	200011	TRANS SILICO PNP	009			DANA	200011
Q15	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q16	200022	TRANS SILICO PNP	012			DANA	200022
Q17	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q18	200035	TRANS SILICO NPN	014			DANA	200035
Q19	200011	TRANS SILICO PNP	009			DANA	200011
Q20	200011	TRANS SILICO PNP	009			DANA	200011
Q21	200035	TRANS SILICO NPN	014			DANA	200035
Q22	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q23	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q24	200022	TRANS SILICO PNP	012			DANA	200022
Q25	200022	TRANS SILICO PNP	012			DANA	200022
Q26	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q27	200040	TRANS SILICO NPN	016			DANA	200040
Q28	200040	TRANS SILICO NPN	016			DANA	200040
Q29	200035	TRANS SILICO NPN	014			DANA	200035
Q30	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q31	200011	TRANS SILICO PNP	009			DANA	200011
Q32	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q33	200011	TRANS SILICO PNP	009			DANA	200011
Q34	200043	TRANS SILICO NPN	2N3565			FAIRCHILD	2N3565
Q35	200035	TRANS SILICO NPN	014			DANA	200035
Q36	200035	TRANS SILICO NPN	014			DANA	200035
Q37	200011	TRANS SILICO PNP	009			DANA	200011
Q38	200011	TRANS SILICO PNP	009			DANA	200011
Q39	200035	TRANS SILICO NPN	014			DANA	200035
Q40	200011	TRANS SILICO PNP	009			DANA	200011
R01	020106	RES WW	100 OHM	.3%	1/8 W	CF ELEC	CF-4012
R02	000392	RES CARBON	0003.9 K	5%	1/4 W1	OHMITE	RC07GF392J
R04	020106	RES WW	100 OHM	.3%	1/8 W	CF ELEC	CF-4012

PARTS LIST

ASSEMBLY 402310 **PC Board Assembly - Amp, 100 MA O.P. w/Variband, V1 Option** A

REF. DESIG.	PART NO.	DESCRIPTION								
R05	000392	RES	CARBON	0003.9	K	5%	1/4 W1	OHMITE	RC07GF392J
R11	000621	RES	CARBON	620	OHM	5%	1/4 W1	OHMITE	RC07GF621J
R12	000152	RES	CARBON	1.5	K	5%	1/4 W1	OHMITE	RC07GF152J
R13	000242	RES	CARBON	2.4	K	5%	1/4 W1	OHMITE	RC07GF242J
R14	000472	RES	CARBON	4.7	K	5%	1/4 W1	OHMITE	RC07GF472J
R15	020424	RES	WW	9.179	K	.05%		JORDAN	J11
R16	020423	RES	WW	3.442	K	.05%		JORDAN	J11
R17	020422	RES	WW	1.530	K	.05%		JORDAN	J11
R18	020421	RES	WW	573.7	OHM	.05%		JORDAN	J11
R19	020420	RES	WW	281	OHM	.05%		CF	M18
R20	402718	ASSY			FSV	2850	V1	DANA	402718
R21	020086	RES	WW	840	OHM	.1%	1/8 W	KELVIN	EP-20
R22	402718	ASSY			FSV	2850	V1	DANA	402718
R23	020079	RES	WW	100	K	.1%	1/8 W	JORDAN	J-11
R24	402718	ASSY			FSV	2850	V1	DANA	402718
R25	402718	ASSY			FSV	2850	V1	DANA	402718
R26	020079	RES	WW	100	K	.1%	1/8 W	JORDAN	J-11
R27	402718	ASSY			FSV	2850	V1	DANA	402718
R28	040092	RES	VARI	20	K			SPECTRO	50-3-1-203
R29	040092	RES	VARI	20	K			SPECTRO	50-3-1-203
R30	011178	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN20X4994F
R31	011178	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN20X4994F
R32	010130	RES	METAL	6.19	K	1%	1/4 W	ELECTRA	RN60D6191F
R33	402718	ASSY			FSV	2850	V1	DANA	402718
R34	010059	RES	METAL	20	K	1%	1/4 W	ELECTRA	RN60D2002F
R35	010059	RES	METAL	20	K	1%	1/4 W	ELECTRA	RN60D2002F
R36	010110	RES	METAL	10	K	1%	1/2 W	ELECTRA	RN65C1002F
R37	040093	RES	VARI	500	OHM			SPECTRO	50-3-1-501
R38	402718	ASSY			FSV	2850	V1	DANA	402718
R39	402718	ASSY			FSV	2850	V1	DANA	402718
R40	020078	RES	WW	50	K	.1%	1/8 W	JORDAN	J-11
R41	020078	RES	WW	50	K	.1%	1/8 W	JORDAN	J-11
R42	020425	RES	WW	10.455	K	.1%		CF	M20
R43	040108	RES	VARI	50	OHM			SPECTROL	50-3
R44	020425	RES	WW	10.455	K	.1%		CF	M20
R45	402718	ASSY			FSV	2850	V1	DANA	402718
R46	040020	RES	VARI	1	K	10%	1/4 W	BOURNS	271-1-102-M
R47	402718	ASSY			FSV	2850	V1	DANA	402718

PARTS LIST

ASSEMBLY 402310 PC Board Assembly - Amp, 100 MA O.P w/Variband, V1 Option A

REF. DESIG.	PART NO.	DESCRIPTION							
R48	402718	ASSY		FSV 2850		V1		DANA	402718
R49	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R50	020104	RES	WW	3.75 K	1%	1/8 W		CF ELEC	CF3133
R51	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R52	010020	RES	METAL	4.99 K	1%	1/4 W		ELECTRA	RN60D4991F
R53	000512	RES	CARBON	5.1 K	5%	1/4 W1		OHMITE	RC07GF512J
R54	000153	RES	CARBON	15 K	5%	1/4 W1		OHMITE	RC07GF153J
R55	000752	RES	CARBON	7.5 K	5%	1/4 W1		OHMITE	RC07GF752J
R56	000123	RES	CARBON	12 K	5%	1/4 W1		OHMITE	RC07GF123J
R57	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R58	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R59	000104	RES	CARBON	100 K	5%	1/4 W1		OHMITE	RC07GF104J
R60	010019	RES	METAL	30.1 K	1%	1/4 W		ELECTRA	RN60B3012F
R61	000153	RES	CARBON	15 K	5%	1/4 W1		OHMITE	RC07GF153J
R62	011334	RES	METAL	2.61 K	1%	1/4 W		ELECTRA	RN60D2611F
R63	010008	RES	METAL	1.4 K	1%	1/4 W		IRC	RN60D142F
R64	000103	RES	CARBON	10 K	5%	1/4 W1		OHMITE	RC07GF103J
R65	000103	RES	CARBON	10 K	5%	1/4 W1		OHMITE	RC07GF103J
R66	000221	RES	CARBON	220 OHM	5%	1/4 W1		OHMITE	RC07GF221J
R67	010027	RES	METAL	499 OHM	1%	1/4 W1		ELECTRA	RN60D4990F
R68	000123	RES	CARBON	12 K	5%	1/4 W1		OHMITE	RC07GF123J
R69	000103	RES	CARBON	10 K	5%	1/4 W1		OHMITE	RC07GF103J
R70	000204	RES	CARBON	200 K	5%	1/4 W		OHMITE	RC07GF204J
R71	000221	RES	CARBON	220 OHM	5%	1/4 W1		OHMITE	RC07GF221J
R72	000823	RES	CARBON	82 K	5%	1/4 W1		OHMITE	RC07GF823J
R73	000222	RES	CARBON	2.2 K	5%	1/4 W1		OHMITE	RC07GF222J
R74	000153	RES	CARBON	15 K	5%	1/4 W1		OHMITE	RC07GF153J
R75	000152	RES	CARBON	1.5 K	5%	1/4 W1		OHMITE	RC07GF152J
R76	020119	RES	WW	680 OHM	1%	1/2 W1		CF ELEC	M-20
R77	000822	RES	CARBON	8.2 K	5%	1/4 W1		OHMITE	RC07GF822J
R78	000223	RES	CARBON	22 K	5%	1/4 W		OHMITE	RC07GF223J
R79	000472	RES	CARBON	4.7 K	5%	1/4 W1		OHMITE	RC07GF472J
R80	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J
R81	000201	RES	CARBON	200 OHM	5%	1/4 W1		OHMITE	RC07GF201J
R82	000201	RES	CARBON	200 OHM	5%	1/4 W1		OHMITE	RC07GF201J
R83	000103	RES	CARBON	10 K	5%	1/4 W1		OHMITE	RC07GF103J
R84	000393	RES	CARBON	39 K	5%	1/4 W		OHMITE	RC07GF393J

PARTS LIST

ASSEMBLY 402310 **PC Board Assembly - Amp, 100 MA O.P w/Variband, V1 Option** A

REF. DESIG.	PART NO.	DESCRIPTION							
R85	000122	RES	CARBON	1.2 K	5%	1/4 W1	OHMITE	RC07GF122J
R86	000510	RES	CARBON	51 OHM	5%	1/4 W1	OHMITE	RC07GF510J
R87	000201	RES	CARBON	200 OHM	5%	1/4 W1	OHMITE	RC07GF201J
R88	000201	RES	CARBON	200 OHM	5%	1/4 W1	OHMITE	RC07GF201J
R89	001159	RES	CARBON	330 OHM	5%	1/2 W	OHMITE	RC20GF331J
R90	001159	RES	CARBON	330 OHM	5%	1/2 W	OHMITE	RC20GF331J
R91	000273	RES	CARBON	27 K	5%	1/4 W1	OHMITE	RC07GF273J
R92	000122	RES	CARBON	1.2 K	5%	1/4 W1	OHMITE	RC07GF122J
R93	000510	RES	CARBON	51 OHM	5%	1/4 W1	OHMITE	RC07GF510J
R94	000124	RES	CARBON	120 K	5%	1/4 W1	OHMITE	RC07GF124J
R95	010086	RES	METAL	9.53 K	1%	1/4 W	ELECTRA	RN60D9531F
R96	010020	RES	METAL	4.99 K	1%	1/4 W	ELECTRA	RN60D4991F
R97	010324	RES	METAL	10.7 K	1%		CORNING	RN60D1072F
R98	010211	RES	METAL	4.42 K	1%		CORNING	RN60D
R99	000622	RES	CARBON	6.2 K	5%	1/4 W1	OHMITE	RC07GF622J
R100	000104	RES	CARBON	100 K	5%	1/4 W1	OHMITE	RC07GF104J
R101	000302	RES	CARBON	3 K	5%	1/4 W1	OHMITE	RC07GF302J
R102	000301	RES	CARBON	300 OHM	5%	1/4 W	OHMITE	RC07GF301J
R103	000162	RES	CARBON	1.6 K	5%	1/4 W	OHMITE	RC07GF162J
R104	000183	RES	CARBON	18 K	5%	1/4 W1	OHMITE	RC07GF183J
R105	000151	RES	CARBON	150 OHM	5%	1/4 W1	OHMITE	RC07GF151J
R106	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R107	000752	RES	CARBON	7.5 K	5%	1/4 W1	OHMITE	RC07GF752J
R108	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J
R109	010082	RES	METAL	9.31 K	1%	1/4 W	ELECTRA	RN60D9311F
R110	040109	RES	VARI	5 K			SPECTROL	50-3
R111	010082	RES	METAL	9.31 K	1%	1/4 W	ELECTRA	RN60D9311F
R112	000202	RES	CARBON	2 K	5%	1/4 W1	OHMITE	RC07GF202J
R113	010088	RES	METAL	8.45 K	1%	1/4 W	ELECTRA	RN60D8451F
R114	011332	RES	METAL	1 K	1%	1/4 W1	ELECTRA	RN60D1001F
R115	010084	RES	METAL	54.9 K	1%	1/4 W	ELECTRA	RN60D5492F
R116	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R117	011332	RES	METAL	1 K	1%	1/4 W1	ELECTRA	RN60D1001F
R118	000102	RES	CARBON	1 K	5%	1/4 W1	OHMITE	RC07GF102J
R119	010113	RES	METAL	15 K	1%	1/4 W	ELECTRA	RN60D1502F
R120	000103	RES	CARBON	10 K	5%	1/4 W1	OHMITE	RC07GF103J
R121	010020	RES	METAL	4.99 K	1%	1/4 W	ELECTRA	RN60D4991F
R122	010086	RES	METAL	9.53 K	1%	1/4 W	ELECTRA	RN60D9531F

PARTS LIST

ASSEMBLY 402310 PC Board Assembly - Amp, 100 MA O.P. w/Variband, V1 Option A

REF. DESIG.	PART NO.	DESCRIPTION							
R123	010087	RES	METAL	11.5 K		1%	1/4 W	ELECTRA	RN60D1152F
R124	000392	RES	CARBON	0003.9 K		5%	1/4 W1	OHMITE	RC07GF392J
R125	000392	RES	CARBON	0003.9K		5%	1/4 W1	OHMITE	RC07GF3 2J
R126	010137	RES	METAL	100	OHM	1%	1/4 W	ELECTRA	RN60D1000F
R127	000102	RES	CARBON	1	K	5%	1/4 W1	OHMITE	RC07GF102J
R128	000471	RES	CARBON	470	OHM	5%	1/4 W1	OHMITE	RC07GF471J
R129	000301	RES	CARBON	300	OHM	5%	1/4 W	OHMITE	RC07GF301J
R130	040022	RES	VARI	500	OHM	10%	1.5 W	CTS	110
R131	000681	RES	CARBON	680	OHM	5%	1/4 W1	OHMITE	RC07GF681J
R132	000681	RES	CARBON	680	OHM	5%	1/4 W1	OHMITE	RC07GF681J
R133	040022	RES	VARI	500	OHM	10%	1.5 W	CTS	110
R134	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R135	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R136	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R137	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R138	000100	RES	CARBON	10	OHM	5%	1/4 W1	OHMITE	RC07GF100J
R139	000392	RES	CARBON	0003.9 K		5%	1/4 W1	OHMITE	RC07GF392J
R140	000392	RES	CARBON	0003.9 K		5%	1/4 W1	OHMITE	RC07GF392J
R141	030003	RES	WW	39	OHM	2W	1/8 W	JORDAN	J-11
R142	000100	RES	CARBON	10	OHM	5%	1/4 W1	OHMITE	RC07GF100J
R143	001682	RES	CARBON	1.5	K	5%	1/2 W	OHMITE	RC20GF152J
R144	000100	RES	CARBON	10	OHM	5%	1/4 W1	OHMITE	RC07GF100J
R145	001682	RES	CARBON	1.5	K	5%	1/2 W	OHMITE	RC20GF152J
R146	030003	RES	WW	39	OHM	2W	1/8 W	JORDAN	J-11
R147	000151	RES	CARBON	150	OHM	5%	1/4 W1	OHMITE	RC07GF151J
R148	020106	RES	WW	100	OHM	.3%	1/8 W	CF ELEC	CF-4012
R149	020106	RES	WW	100	OHM	.3%	1/8 W	CF ELEC	CF-4012
R150	000101	RES	CARBON	100	OHM	5%	1/4 W1	OHMITE	RC07GF101J

PARTS LIST

ASSEMBLY 402311 **PC Board Assembly- Amp, 100 MA O.P. w/Variband V2 Option** A

REF. DESIG.	PART NO.	DESCRIPTION			
CR01	211083	DIODE SILICO 018	1	DANA	211083
CR02	211083	DIODE SILICO 018	1	DANA	211083
CR03	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR04	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR05	211083	DIODE SILICO 018	1	DANA	211083
CR06	211083	DIODE SILICO 018	1	DANA	211083
CR07	211083	DIODE SILICO 018	1	DANA	211083
CR08	211083	DIODE SILICO 018	1	DANA	211083
CR09	211083	DIODE SILICO 018	1	DANA	211083
CR10	210004	DIODE SILICO SD4		DIODES IN SD4	
CR11	210004	DIODE SILICO SD4		DIODES IN SD4	
CR12	210004	DIODE SILICO SD4		DIODES IN SD4	
CR13	211083	DIODE SILICO 018	1	DANA	211083
CR14	211083	DIODE SILICO 018	1	DANA	211083
CR15	211083	DIODE SILICO 018	1	DANA	211083
CR16	211083	DIODE SILICO 018	1	DANA	211083
CR17	211083	DIODE SILICO 018	1	DANA	211083
CR18	211083	DIODE SILICO 018	1	DANA	211083
CR19	211083	DIODE SILICO 018	1	DANA	211083
CR20	211083	DIODE SILICO 018	1	DANA	211083
CR21	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR22	211083	DIODE SILICO 018	1	DANA	211083
CR23	211083	DIODE SILICO 018	1	DANA	211083
CR24	221177	DIODE SILICO ZENER 1/4	W1	MOTOROLA	M2.4AZ5
CR25	210004	DIODE SILICO SD4		DIODES IN SD4	
CR26	210004	DIODE SILICO SD4		DIODES IN SD4	
CR27	210004	DIODE SILICO SD4		DIODES IN SD4	
CR28	210004	DIODE SILICO SD4		DIODES IN SD4	
CR29	210004	DIODE SILICO SD4		DIODES IN SD4	
CR30	210004	DIODE SILICO SD4		DIODES IN SD4	
CR31	210004	DIODE SILICO SD4		DIODES IN SD4	
CR32	210004	DIODE SILICO SD4		DIODES IN SD4	
CR33	220016	DIODE SILICO ZENER 1N964B		MOTOROLA 1N964B	
CR34	220016	DIODE SILICO ZENER 1N964B		MOTOROLA 1N964B	
CR35	210004	DIODE SILICO SD4		DIODES IN SD4	
CR36	220011	DIODE SILICO ZENER 1N968A	1	MOTOROLA 1N968A	
CR37	220011	DIODE SILICO ZENER 1N968A	1	MOTOROLA 1N968A	
CR38	210004	DIODE SILICO SD4		DIODES IN SD4	

PARTS LIST

ASSEMBLY 402311 **PC Board Assembly - Amp, 100 MA O.P. w/Variband V2 Option** A

REF. DESIG.	PART NO.	DESCRIPTION							
CR39	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR40	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR41	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR42	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR43	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR44	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR45	210004	DIODE SILICO	SD4				DIODES IN SD4		
CR46	210004	DIODE SILICO	SD4				DIODES IN SD4		
C01	121092	CAP MYLAR	.0022 MFD	100 V	10%		CDE	WMF1D22	
C02	121092	CAP MYLAR	.0022 MFD	100 V	10%		CDE	WMF1D22	
C03	101174	CAP CERAM	.001 MFD	500 V	10%1		AEROVOX	SCD3X5F	
C04	100006	CAP CERAM	10 PFD	500 V	10%1		AEROVOX	TCD-N750	
C05	130004	CAP CERAM	2-8 PFD	500 V	10%		ERIE	538-00289R	
C06	101641	CAP CERAM	470 PFD	500 V	10%1		AEROVOX	SCD1X5F	
C07	121093	CAP MYLAR	.047 MFD	100 V	10%1		CDE	WMF1S47	
C08	121091	CAP MYLAR	.033 MFD	100 V	10%1		CDE	WMF1533	
C09	121090	CAP MYLAR	.015 MFD	100 V	10%1		CDE	WMF1S15	
C10	121088	CAP MYLAR	.01 MFD	100 V	10%		CDE	WMF1S1	
C11	121088	CAP MYLAR	.01 MFD	100 V	10%		CDE	WMF1S1	
C12	101145	CAP CERAM	100 PFD	500 V	10%1		AEROVOX	SCD1X5F	
C13	101145	CAP CERAM	100 PFD	500 V	10%1		AEROVOX	SCD1X5F	
C14	101641	CAP CERAM	470 PFD	500 V	10%1		AEROVOX	SCD1X5F	
C15	130004	CAP CERAM	2-8 PFD	500 V	10%		ERIE	538-00289R	
C17	100009	CAP CERAM	5 PFD	500 V	10%		AEROVOX	TCD-N750	
C18	121088	CAP MYLAR	.01 MFD	100 V	10%		CDE	WMF1S1	
C19	111262	CAP ELECT	10 MFD	25 V	20%1		SPRAGUE	TE1204	
C20	121091	CAP MYLAR	.033 MFD	100 V	10%1		CDE	WMF1533	
C21	101641	CAP CERAM	470 PFD	500 V	10%1		AEROVOX	SCD1X5F	
C22	101174	CAP CERAM	.001 MFD	500 V	10%1		AEROVOX	SCD3X5F	
C23	101098	CAP CERAM	330 PFD	500 V	10%1		AEROVOX	SCD1X5F	
C24	121092	CAP MYLAR	.0022 MFD	100 V	10%		CDE	WMF1D22	
C25	120129	CAP MYLAR	1.5 MFD	100 V	5%	IMB	XT2B155J		
C26	120130	CAP MYLAR	.15 MFD	100 V	5%	IMB	XT2B154J		
C27	120131	CAP MYLAR	.015 MFD	100 V	5%	IMB	XT2B153J		
C28	120132	CAP MYLAR	.0013 MFD	100 V	5%	IMB	XT2B132J		
C29	120129	CAP MYLAR	1.5 MFD	100 V	5%	IMB	XT2B155J		
C30	120130	CAP MYLAR	.15 MFD	100 V	5%	IMB	XT2B154J		
C31	120131	CAP MYLAR	.015 MFD	100 V	5%	IMB	XT2B153J		

PARTS LIST

ASSEMBLY 402311 **PC Board Assembly - Amp, 100 MA O.P. w/Variband V2 Option** A

REF. DESIG.	PART NO.	DESCRIPTION								
C32	120132	CAP	MYLAR	.0013	MFD	100	V	5%	IMB	XT2B132J
C33	120129	CAP	MYLAR	1.5	MFD	100	V	5%	IMB	XT2B155J
C34	120130	CAP	MYLAR	.15	MFD	100	V	5%	IMB	XT2B154J
C35	120131	CAP	MYLAR	.015	MFD	100	V	5%	IMB	XT2B153J
C36	120132	CAP	MYLAR	.0013	MFD	100	V	5%	IMB	XT2B132J
C37	100013	CAP	CERAM	15	PFD	500	V	10%	AEROVOX	TCD-N750
C38	101175	CAP	CERAM	220	PFD	500	V	10%1	AEROVOX	SCD1X5F
C39	101642	CAP	CERAM	150	PFD	500	V	10%1	AEROVOX	SCD2X5F
C40	121090	CAP	MYLAR	.015	MFD	100	V	10%1	CDE	WMF1S15
C41	121473	CAP	MYLAR	.0015	MFD	100	V	10%1	CDE	WMF1S47
C42	101145	CAP	CERAM	100	PFD	500	V	10%1	AEROVOX	SCD1X5F
C43	101145	CAP	CERAM	100	PFD	500	V	10%1	AEROVOX	SCD1X5F
C44	101175	CAP	CERAM	220	PFD	500	V	10%1	AEROVOX	SCD1X5F
C45	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
C46	111095	CAP	ELECT	1	MFD	25	V	20%1	SPRAGUE	TE1200
C47	101182	CAP	CERAM	47	PFD	500	V	10%1	AEROVOX	TCD-N750
C48	101182	CAP	CERAM	47	PFD	500	V	10%1	AEROVOX	TCD-N750
C49	111095	CAP	ELECT	1	MFD	25	V	20%1	SPRAGUE	TE1200
C50	121468	CAP	MYLAR	.022	MFD	100	V	10%1	CDE	WMF1S22
C51	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
C52	101182	CAP	CERAM	47	PFD	500	V	10%1	AEROVOX	TCD-N750
C53	110060	CAP	ELECT	50	MFD	25	V		SPRAGUE	TE1209
C54	110060	CAP	ELECT	50	MFD	25	V		SPRAGUE	TE1209
C55	101182	CAP	CERAM	47	PFD	500	V	10%1	AEROVOX	TCD-N750
C56	110062	CAP	ELECT	500	MFD	50	V		SPRAGUE	39D507G050L4
C57	110062	CAP	ELECT	500	MFD	50	V		SPRAGUE	39D507G050L4
C58	110061	CAP	ELECT	100	MFD	50	V		SPRAGUE	39D107G050EJ4
C59	110061	CAP	ELECT	100	MFD	50	V		SPRAGUE	39D107G050EJ4
C60	120190	CAP	MYLAR	.15	MFD	400	V		CD	WMF4915
C61	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
C62	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
C63	100017	CAP	CERAM	.01	MFD	200	V	10%	SPRAGUE	TH-S10
C64	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
C65	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
C66	101174	CAP	CERAM	.001	MFD	500	V	10%1	AEROVOX	SCD3X5F
Q01	200043	TRANS	SILICO NPN		2N3565				FAIRCHILD	2N3565
Q02	402719	ASSY			FSV 2850		V2		DANA	402719
Q03	200022	TRANS	SILICO PNP		012				DANA	200022

PARTS LIST

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REF. DESIG.	PART NO.	DESCRIPTION			
Q04	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q05	201285	TRANS DUAL NPN	016S	DANA	201285
Q06	200078	TRANS SILICO NPN	FSV	DANA	200078
Q07	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q08	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q09	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q10	200035	TRANS SILICO NPN	014	DANA	200035
Q11	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q12	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q13	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q14	200011	TRANS SILICO PNP	009	DANA	200011
Q15	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q16	200022	TRANS SILICO PNP	012	DANA	200022
Q17	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q18	200035	TRANS SILICO NPN	014	DANA	200035
Q19	200011	TRANS SILICO PNP	009	DANA	200011
Q20	200011	TRANS SILICO PNP	009	DANA	200011
Q21	200035	TRANS SILICO NPN	014	DANA	200035
Q22	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q23	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q24	200022	TRANS SILICO PNP	012	DANA	200022
Q25	200022	TRANS SILICO PNP	012	DANA	200022
Q26	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q27	200040	TRANS SILICO NPN	016	DANA	200040
Q28	200040	TRANS SILICO NPN	016	DANA	200040
Q29	200035	TRANS SILICO NPN	014	DANA	200035
Q30	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q31	200011	TRANS SILICO PNP	009	DANA	200011
Q32	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q33	200011	TRANS SILICO PNP	009	DANA	200011
Q34	200043	TRANS SILICO NPN	2N3565	FAIRCHILD	2N3565
Q35	200035	TRANS SILICO NPN	014	DANA	200035
Q36	200035	TRANS SILICO NPN	014	DANA	200035
Q37	200011	TRANS SILICO PNP	009	DANA	200011
Q38	200011	TRANS SILICO PNP	009	DANA	200011
Q39	200035	TRANS SILICO NPN	014	DANA	200035
Q40	200011	TRANS SILICO PNP	009	DANA	200011

PARTS LIST

ASSEMBLY 402311 PC Board Assembly - Amp, 100 MA O.P. w/Variband V2 Option A

REF. DESIG.	PART NO.	DESCRIPTION								
R01	020106	RES	WW	100	OHM	.3%	1/8	W	CF ELEC	CF-4012
R02	000392	RES	CARBON	0003.9	K	5%	1/4	W1	OHMITE	RC07GF392J
R03	010111	RES	METAL	1	MEG	1%			CORNING	RN65C1004F
R04	020106	RES	WW	100	OHM	.3%	1/8	W	CF ELEC	CF-4012
R05	000392	RES	CARBON	0003.9	K	5%	1/4	W1	OHMITE	RC07GF392J
R06	010111	RES	METAL	1	MEG	1%			CORNING	RN65C1004F
R07	402719	ASSY			FSV	2850	V2		DANA	402719
R08	020097	RES	WW	10	K	.1%	1/8	W	JORDAN	J-11
R09	020097	RES	WW	10	K	.1%	1/8	W	JORDAN	J-11
R10	040093	RES	VARI	500	OHM				SPECTRO	50-3-1-501
R11	000621	RES	CARBON	620	OHM	5%	1/4	W1	OHMITE	RC07GF621J
R12	000152	RES	CARBON	1.5	K	5%	1/4	W1	OHMITE	RC07GF152J
R13	000242	RES	CARBON	2.4	K	5%	1/4	W1	OHMITE	RC07GF242J
R14	000472	RES	CARBON	4.7	K	5%	1/4	W1	OHMITE	RC07GF472J
R15	020424	RES	WW	9.179	K	.05%			JORDAN	J11
R16	020423	RES	WW	3.442	K	.05%			JORDAN	J11
R17	020422	RES	WW	1.530	K	.05%			JORDAN	J11
R18	020421	RES	WW	573.7	OHM	.05%			JORDAN	J11
R19	020420	RES	WW	281	OHM	.05%			CF	M18
R20	402719	ASSY			FSV	2850	V2		DANA	402719
R21	020086	RES	WW	840	OHM	.1%	1/8	W	KELVIN	EP-20
R22	402719	ASSY			FSV	2850	V2		DANA	402719
R23	020079	RES	WW	100	K	.1%	1/8	W	JORDAN	J-11
R24	402719	ASSY			FSV	2850	V2		DANA	402719
R25	402719	ASSY			FSV	2850	V2		DANA	402719
R26	020079	RES	WW	100	K	.1%	1/8	W	JORDAN	J-11
R27	402719	ASSY			FSV	2850	V2		DANA	402719
R28	040092	RES	VARI	20	K				SPECTRO	50-3-1-203
R29	040092	RES	VARI	20	K				SPECTRO	50-3-1-203
R30	011178	RES	METAL	4.99	K	1%	1/4	W	ELECTRA	RN20X4994F
R31	011178	RES	METAL	4.99	K	1%	1/4	W	ELECTRA	RN20X4994F
R32	010130	RES	METAL	6.19	K	1%	1/4	W	ELECTRA	RN60D6191F
R33	402719	ASSY			FSV	2850	V2		DANA	402719
R34	010059	RES	METAL	20	K	1%	1/4	W	ELECTRA	RN60D2002F
R35	010059	RES	METAL	20	K	1%	1/4	W	ELECTRA	RN60D2002F
R36	010110	RES	METAL	10	K	1%	1/2	W	ELECTRA	RN65C1002F
R37	040093	RES	VARI	500	OHM				SPECTRO	50-3-1-501
R38	402719	ASSY			FSV	2850	V2		DANA	402719

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ASSEMBLY 402311 **PC Board Assembly - Amp, 100 MA O.P. w/Variband V2 Option** A

REF. DESIG.	PART NO.	DESCRIPTION								
R39	402719	ASSY			FSV 2850	V2		DANA	402719	
R40	020078	RES	WW	50	K	.1%	1/8 W	JORDAN	J-11	
R41	020078	RES	WW	50	K	.1%	1/8 W	JORDAN	J-11	
R42	020425	RES	WW	10.455	K	.1%		CF	M20	
R43	040108	RES	VARI	50	OHM			SPECTROL	50-3	
R44	020425	RES	WW	10.455	K	.1%		CF	M20	
R45	402719	ASSY			FSV 2850	V2		DANA	402719	
R46	040020	RES	VARI	1	K	10%	1/4 W	BOURNS	271-1-102-M	
R47	402719	ASSY			FSV 2850	V2		DANA	402719	
R48	402719	ASSY			FSV 2850	V2		DANA	402719	
R49	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F	
R50	020104	RES	WW	3.75	K	1%	1/8 W	CF ELEC	CF3133	
R51	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F	
R52	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F	
R53	000512	RES	CARBON	5.1	K	5%	1/4 W1	OHMITE	RC07GF512J	
R54	000153	RES	CARBON	15	K	5%	1/4 W1	OHMITE	RC07GF153J	
R55	000752	RES	CARBON	7.5	K	5%	1/4 W1	OHMITE	RC07GF752J	
R56	000123	RES	CARBON	12	K	5%	1/4 W1	OHMITE	RC07GF123J	
R57	000393	RES	CARBON	39	K	5%	1/4 W	OHMITE	RC07GF393J	
R58	000393	RES	CARBON	39	K	5%	1/4 W	OHMITE	RC07GF393J	
R59	000104	RES	CARBON	100	K	5%	1/4 W1	OHMITE	RC07GF104J	
R60	010019	RES	METAL	30.1	K	1%	1/4 W	ELECTRA	RN60B3012F	
R61	000153	RES	CARBON	15	K	5%	1/4 W1	OHMITE	RC07GF153J	
R62	011334	RES	METAL	2.61	K	1%	1/4 W	ELECTRA	RN60D2611F	
R63	010008	RES	METAL	1.4	K	1%	1/4 W	IRC	RN60D142F	
R64	000103	RES	CARBON	10	K	5%	1/4 W1	OHMITE	RC07GF103J	
R65	000103	RES	CARBON	10	K	5%	1/4 W1	OHMITE	RC07GF103J	
R66	000221	RES	CARBON	220	OHM	5%	1/4 W1	OHMITE	RC07GF221J	
R67	010027	RES	METAL	499	OHM	1%	1/4 W1	ELECTRA	RN60D4990F	
R68	000123	RES	CARBON	12	K	5%	1/4 W1	OHMITE	RC07GF123J	
R69	000103	RES	CARBON	10	K	5%	1/4 W1	OHMITE	RC07GF103J	
R70	000204	RES	CARBON	200	K	5%	1/4 W	OHMITE	RC07GF204J	
R71	000221	RES	CARBON	220	OHM	5%	1/4 W1	OHMITE	RC07GF221J	
R72	000823	RES	CARBON	82	K	5%	1/4 W1	OHMITE	RC07GF823J	
R73	000222	RES	CARBON	2.2	K	5%	1/4 W1	OHMITE	RC07GF222J	
R74	000153	RES	CARBON	15	K	5%	1/4 W1	OHMITE	RC07GF153J	
R75	000152	RES	CARBON	1.5	K	5%	1/4 W1	OHMITE	RC07GF152J	

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REF. DESIG.	PART NO.	DESCRIPTION							
R76	020119	RES	WW	680	OHM	1%	1/2 W1	CF ELEC	M-20
R77	000822	RES	CARBON	8.2	K	5%	1/4 W1	OHMITE	RC07GF822J
R78	000223	RES	CARBON	22	K	5%	1/4 W	OHMITE	RC07GF223J
R79	000472	RES	CARBON	4.7	K	5%	1/4 W1	OHMITE	RC07GF472J
R80	000393	RES	CARBON	39	K	5%	1/4 W	OHMITE	RC07GF393J
R81	000201	RES	CARBON	200	OHM	5%	1/4 W1	OHMITE	RC07GF201J
R82	000201	RES	CARBON	200	OHM	5%	1/4 W1	OHMITE	RC07GF201J
R83	000103	RES	CARBON	10	K	5%	1/4 W1	OHMITE	RC07GF103J
R84	000393	RES	CARBON	39	K	5%	1/4 W	OHMITE	RC07GF393J
R85	000122	RES	CARBON	1.2	K	5%	1/4 W1	OHMITE	RC07GF122J
R86	000510	RES	CARBON	51	OHM	5%	1/4 W1	OHMITE	RC07GF510J
R87	000201	RES	CARBON	200	OHM	5%	1/4 W1	OHMITE	RC07GF201J
R88	000201	RES	CARBON	200	OHM	5%	1/4 W1	OHMITE	RC07GF201J
R89	001159	RES	CARBON	330	OHM	5%	1/2 W	OHMITE	RC20GF331J
R90	001159	RES	CARBON	330	OHM	5%	1/2 W	OHMITE	RC20GF331J
R91	000273	RES	CARBON	27	K	5%	1/4 W1	OHMITE	RC07GF273J
R92	000122	RES	CARBON	1.2	K	5%	1/4 W1	OHMITE	RC07GF122J
R93	000510	RES	CARBON	51	OHM	5%	1/4 W1	OHMITE	RC07GF510J
R94	000124	RES	CARBON	120	K	5%	1/4 W1	OHMITE	RC07GF124J
R95	010086	RES	METAL	9.53	K	1%	1/4 W	ELECTRA	RN60D9531F
R96	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F
R97	010324	RES	METAL	10.7	K	1%		CORNING	RN60D1072F
R98	010211	RES	METAL	4.42	K	1%		CORNING	RN60D
R99	000622	RES	CARBON	6.2	K	5%	1/4 W1	OHMITE	RC07GF622J
R100	000104	RES	CARBON	100	K	5%	1/4 W1	OHMITE	RC07GF104J
R101	000302	RES	CARBON	3	K	5%	1/4 W1	OHMITE	RC07GF302J
R102	000301	RES	CARBON	300	OHM	5%	1/4 W	OHMITE	RC07GF301J
R103	000162	RES	CARBON	1.6	K	5%	1/4 W	OHMITE	RC07GF162J
R104	000183	RES	CARBON	18	K	5%	1/4 W1	OHMITE	RC07GF183J
R105	000151	RES	CARBON	150	OHM	5%	1/4 W1	OHMITE	RC07GF151J
R106	000202	RES	CARBON	2	K	5%	1/4 W1	OHMITE	RC07GF202J
R107	000752	RES	CARBON	7.5	K	5%	1/4 W1	OHMITE	RC07GF752J
R108	000103	RES	CARBON	10	K	5%	1/4 W1	OHMITE	RC07GF103J
R109	010082	RES	METAL	9.31	K	1%	1/4 W	ELECTRA	RN60D9311F
R110	040109	RES	VARI	5	K			SPECTROL	50-3
R111	010082	RES	METAL	9.31	K	1%	1/4 W	ELECTRA	RN60D9311F
R112	000202	RES	CARBON	2	K	5%	1/4 W1	OHMITE	RC07GF202J
R113	010088	RES	METAL	8.45	K	1%	1/4 W	ELECTRA	RN60D8451F

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ASSEMBLY 402311 **PC Board Assembly - Amp, 100 MA O.P. w/Variband V2 Option** A

REF. DESIG.	PART NO.	DESCRIPTION							
R114	011332	RES	METAL	1	K	1%	1/4 W1	ELECTRA	RN60D1001F
R115	010084	RES	METAL	54.9	K	1%	1/4 W	ELECTRA	RN60D5492F
R116	000102	RES	CARBON	1	K	5%	1/4 W1	OHMITE	RC07GF102J
R117	011332	RES	METAL	1	K	1%	1/4 W1	ELECTRA	RN60D1001F
R118	000102	RES	CARBON	1	K	5%	1/4 W1	OHMITE	RC07GF102J
R119	010113	RES	METAL	15	K	1%	1/4 W	ELECTRA	RN60D1502F
R120	000103	RES	CARBON	10	K	5%	1/4 W1	OHMITE	RC07GF103J
R121	010020	RES	METAL	4.99	K	1%	1/4 W	ELECTRA	RN60D4991F
R122	010086	RES	METAL	9.53	K	1%	1/4 W	ELECTRA	RN60D9531F
R123	010087	RES	METAL	11.5	K	1%	1/4 W	ELECTRA	RN60D1152F
R124	000392	RES	CARBON	0003.9	K	5%	1/4 W1	OHMITE	RC07GF392J
R125	000392	RES	CARBON	0003.9	K	5%	1/4 W1	OHMITE	RC07GF392J
R126	010137	RES	METAL	100	OHM	1%	1/4 W	ELECTRA	RN60D1000F
R127	000102	RES	CARBON	1	K	5%	1/4 W1	OHMITE	RC07GF102J
R128	000471	RES	CARBON	470	OHM	5%	1/4 W1	OHMITE	RC07GF471J
R129	000301	RES	CARBON	300	OHM	5%	1/4 W	OHMITE	RC07GF301J
R130	040022	RES	VARI	500	OHM	10%	1.5 W	CTS	110
R131	000681	RES	CARBON	680	OHM	5%	1/4 W1	OHMITE	RC07GF681J
R132	000681	RES	CARBON	680	OHM	5%	1/4 W1	OHMITE	RC07GF681J
R133	040022	RES	VARI	500	OHM	10%	1.5 W	CTS	110
R134	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R135	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R136	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R137	001699	RES	CARBON	20	OHM	5%	1/2 W	OHMITE	RC20GF200J
R138	000100	RES	CARBON	10	OHM	5%	1/4 W1	OHMITE	RC07GF100J
R139	000392	RES	CARBON	0003.9	K	5%	1/4 W1	OHMITE	RC07GF392J
R140	000392	RES	CARBON	0003.9	K	5%	1/4 W1	OHMITE	RC07GF392J
R141	030003	RES	WW	39	OHM	2W	1/8 W	JORDAN	J-11
R142	000100	RES	CARBON	10	OHM	5%	1/4 W1	OHMITE	RC07GF100J
R143	001682	RES	CARBON	1.5	K	5%	1/2 W	OHMITE	RC20GF152J
R144	000100	RES	CARBON	10	OHM	5%	1/4 W1	OHMITE	RC07GF100J
R145	001682	RES	CARBON	1.5	K	5%	1/2 W	OHMITE	RC20GF152J
R146	030003	RES	WW	39	OHM	2W	1/8 W	JORDAN	J-11
R147	000151	RES	CARBON	150	OHM	5%	1/4 W1	OHMITE	RC07GF151J
R148	020106	RES	WW	100	OHM	.3%	1/8 W	CF ELEC	CF-4012
R149	020106	RES	WW	100	OHM	.3%	1/8 W	CF ELEC	CF-4012
R150	000101	RES	CARBON	100	OHM	5%	1/4 W1	OHMITE	RC07GF101J

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